TOWARDS SUSTAINABLE GROUND STATIONS

Marc Roubert - ESA
Kennedy Space Centre
Oct. 2014

Triple 20

In 2010, ESA committed itself to :

Reduce by 20%* its CO_2 emissions

Reduce by 20%* its energy consumption

Before 2020

***Baseline 2007**

Our journey towards a better environment

The presentation will:

- Give examples of actions already taken to improve energy efficiency
- Introduce some forthcoming projects
- Give some thought to the future

ACTIONS ALREADY TAKEN

REPLACEMENT OF LIGHTS

REPLACEMENT OF LIGHTS

We have replaced in our station of Cebreros – SPAIN (Deep Space Antenna 2) traditional fluorescent lights

REPLACEMENT OF LIGHTS

by modern
LED luminaires

REPLACEMENT OF LIGHTS

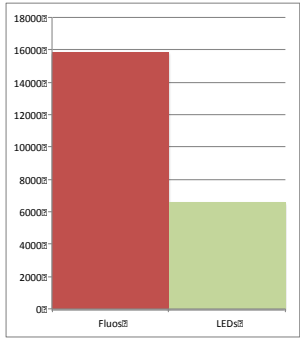
LIGHTS REPLACEMENT – Facts and Figures

- Improved comfort for the users by eliminating flickering of the fluorescent lights.
  This is almost imperceptible but can have disturbing effects on some people (headache e.g.)

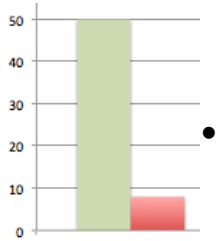
- Better illumination levels: we were below the levels (500 lux) required by the European and international standards (EN 12464-1 and ISO 8995)
  – This is not the case any longer.

REPLACEMENT OF LIGHTS

LIGHTS REPLACEMENT – Facts and Figures



- Savings:
  more than 220 panels have been replaced.
  Each contained 4 tubes of 18W (72W)
  Replaced by 30W LED panels



  - ➢ Generating an estimated saving of **29000 kWh per year**!

- The LEDs have a lifetime of about 50000 h (16 years of usage!) compared to 8000h for the tubes (comparatively 2.5 years)

- Costs have been reduced by about **5k€** per year

- Investment repaid in less than **4 years**

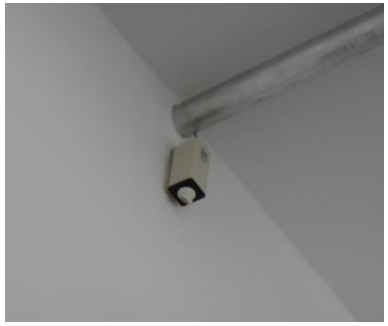
ACTIONS ALREADY TAKEN

ILLUMINATION & PRESENCE MONITORING

ILLUMINATION AND PRESENCE MONITORING

Taking advantage of the total refurbishment of an entire floor (900 sq.m) we have introduced:

- An illumination monitoring device



- A presence detector

ILLUMINATION AND PRESENCE MONITORING

ILLUMINATION MONITORING - What does it do?

- You set up your preferred illumination level in your office
- Throughout the day the illumination sensor dims up or down the light in your office depending on the outside light.

ILLUMINATION AND PRESENCE MONITORING

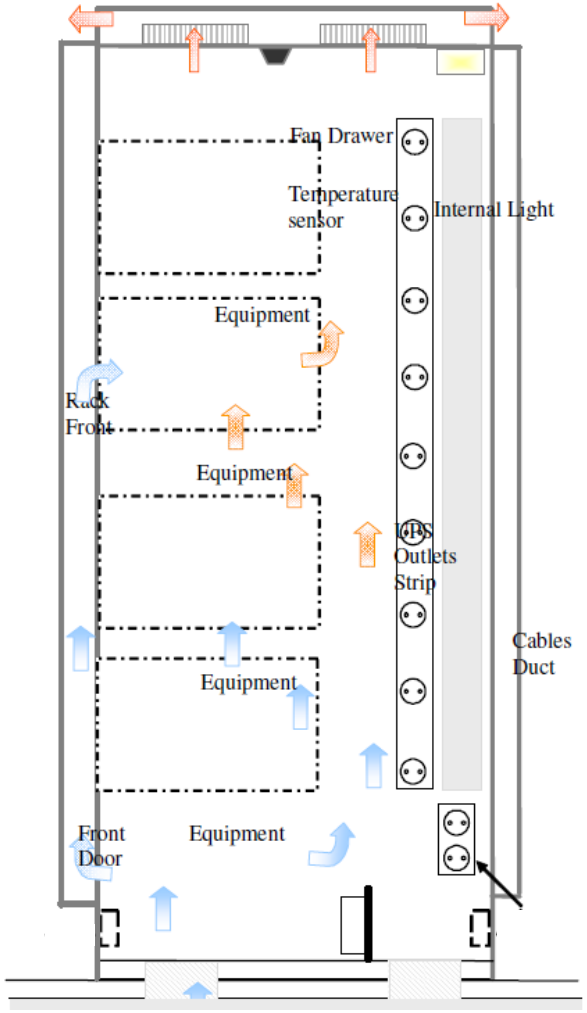
PRESENCE MONITORING - What does it do?

- You leave your office for more than 15 minutes: it turns off your lights…
- When you return: it switches them back on to the dimmed level they were before you left…
- Incidentally we also use it to turn the heating down

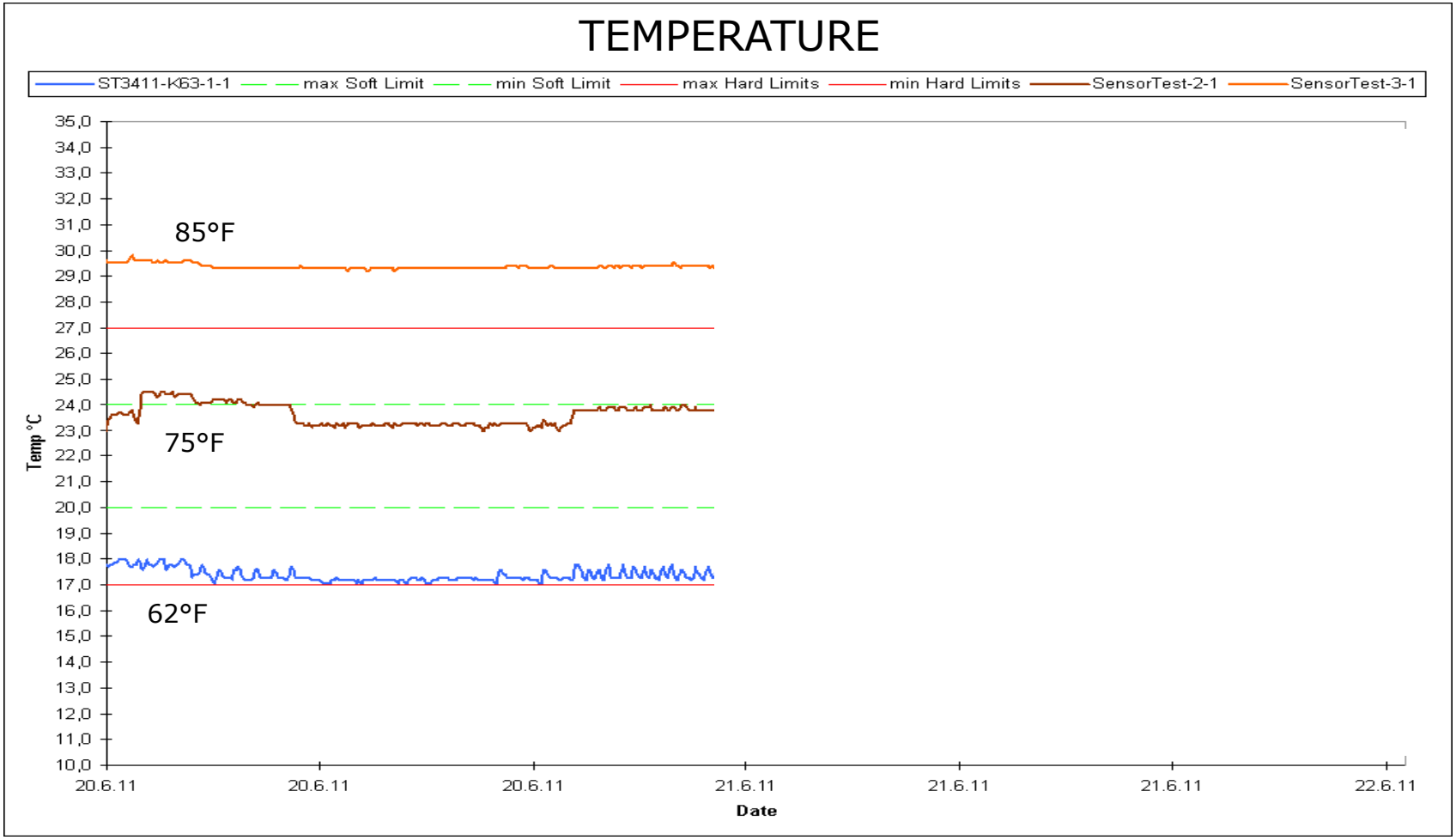
DATA CENTRE COOLING

DATA CENTRE COOLING

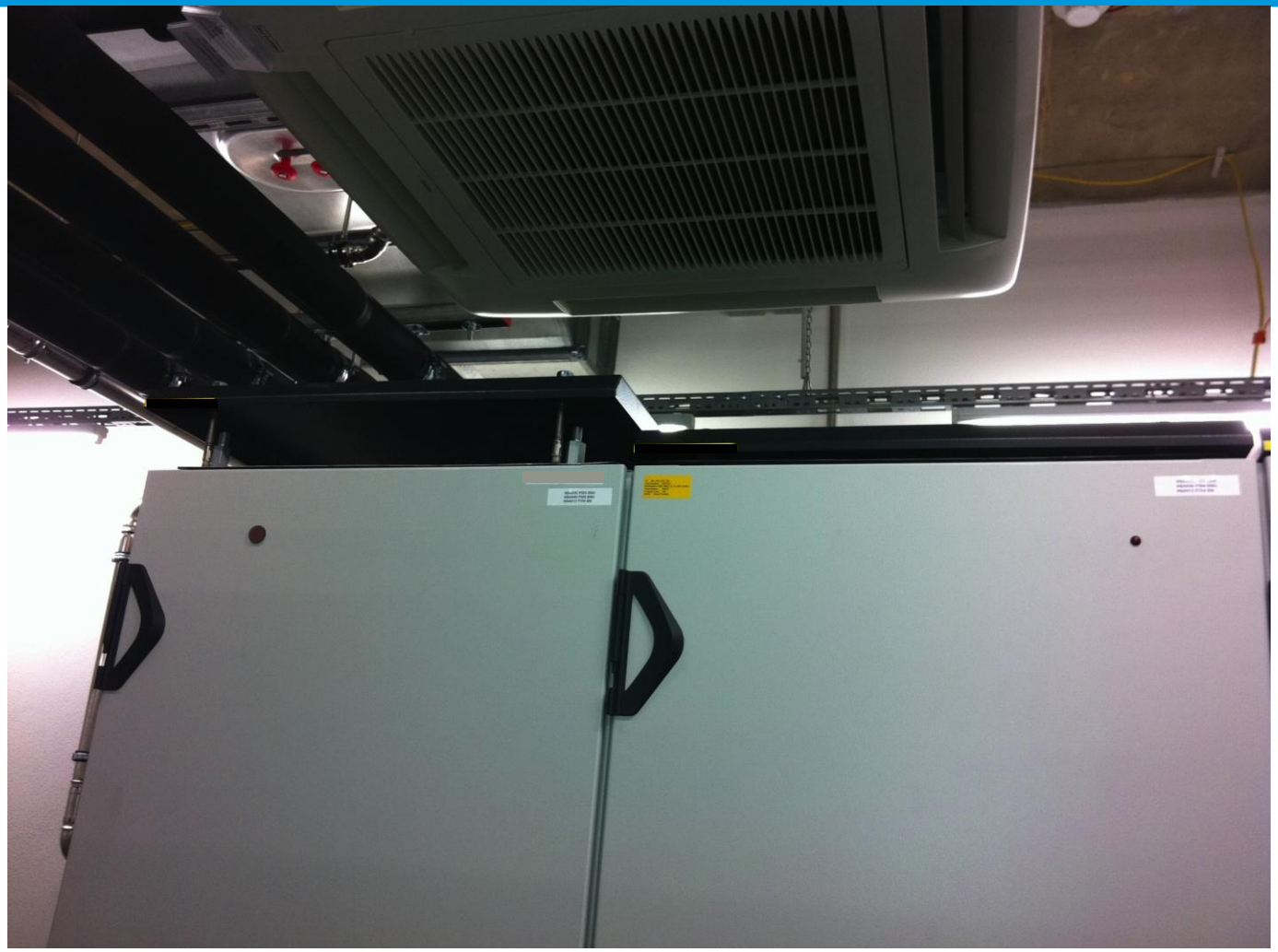
Historically this is how a rack was cooled in our data centres



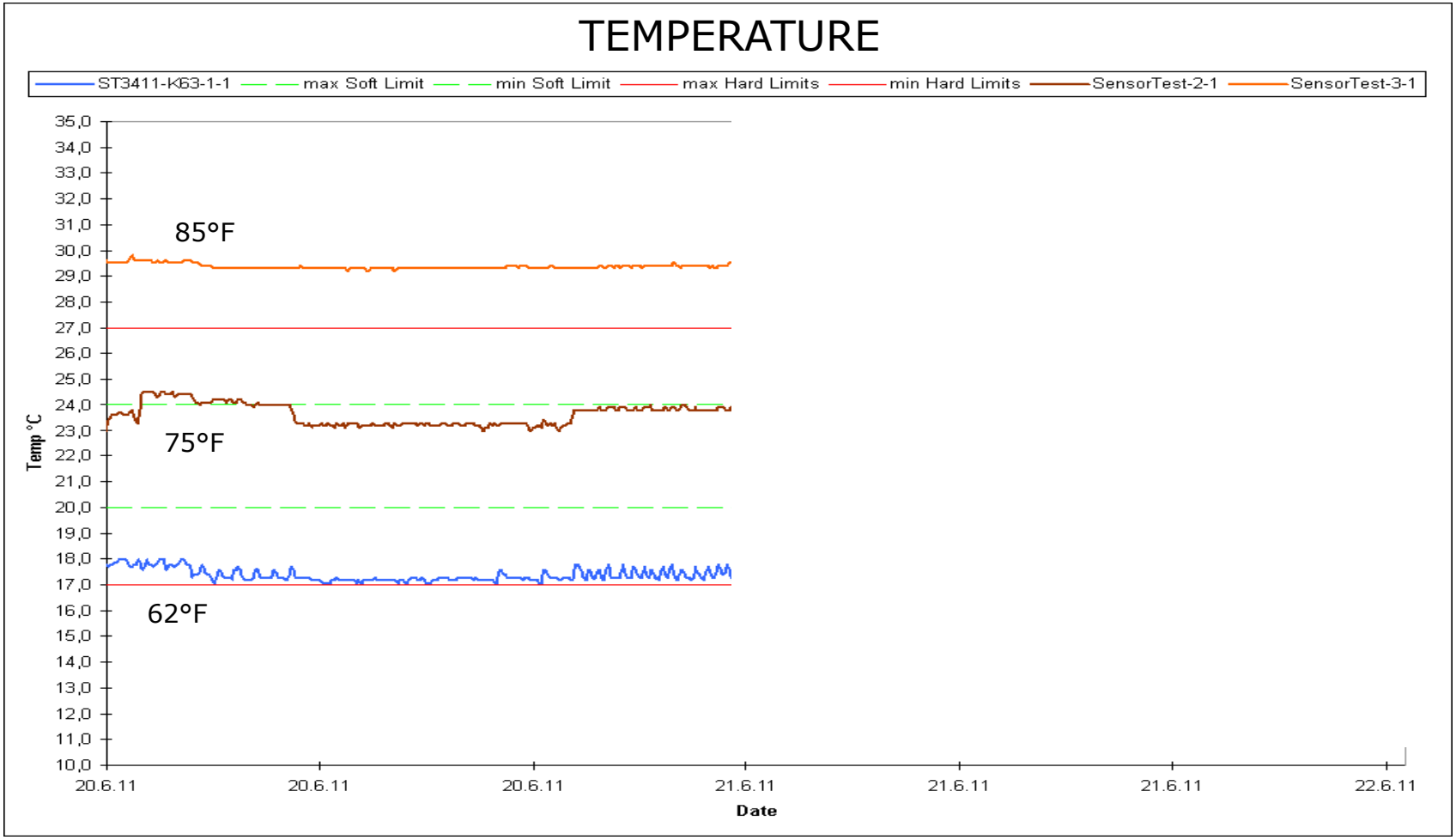
DATA CENTRE COOLING
Improved airflow in racks



DATA CENTRE COOLING



DATA CENTRE COOLING
Improved airflow in racks



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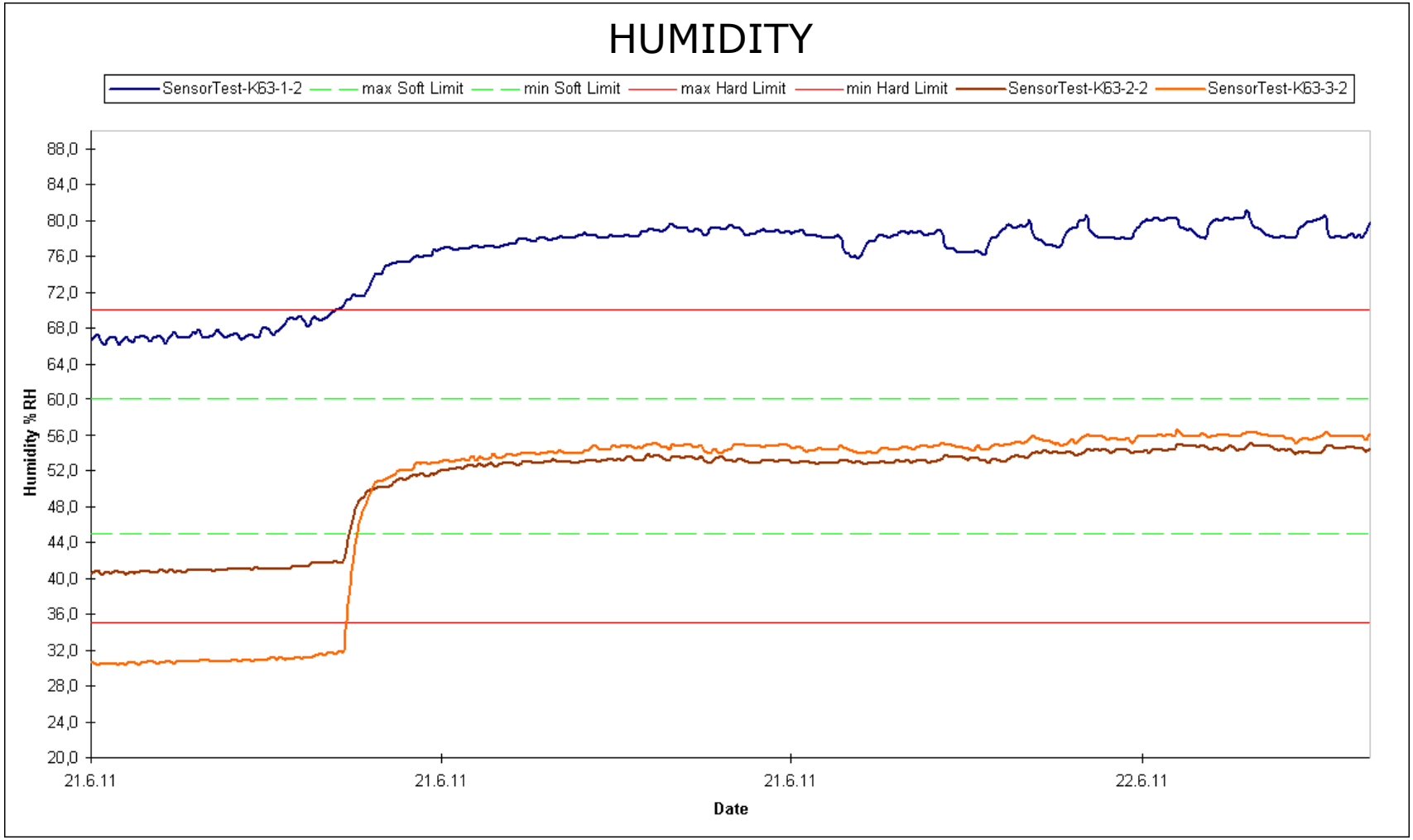
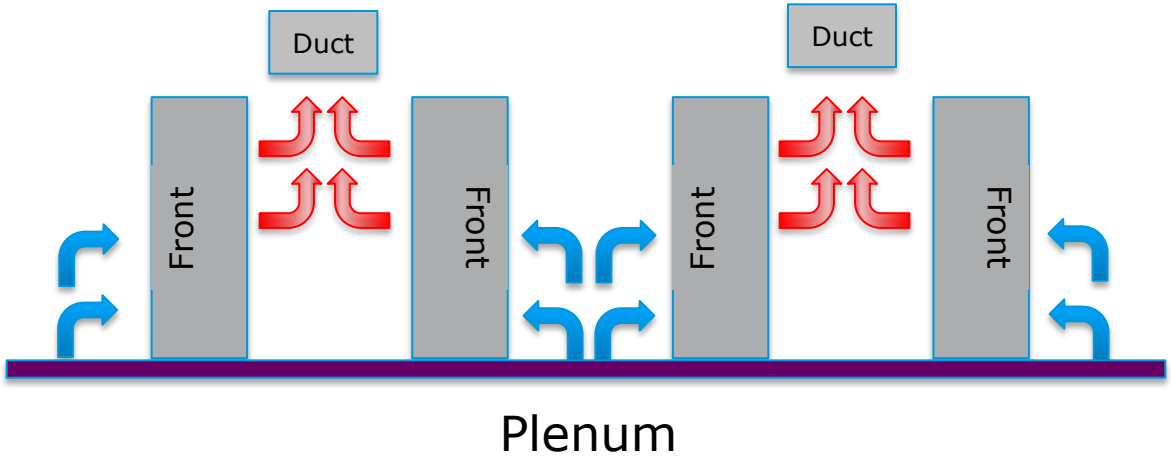
Improved airflow in racks



COLD AISLE – WARM AISLE ALTERNANCE



DATA CENTRE COOLING

RADIO-FREQUENCY AMPLIFIERS

RADIO-FREQUENCY AMPLIFIERS
X-Band High Power Amplifier (20 kW)

A TYPICAL 20 kW AMPLIFIER

Its power consumption is about **90 kW**

Its direct yearly consumption is in the range of **300 MWh**

Additional consumption generated by cooling systems.

RADIO-FREQUENCY AMPLIFIERS
X-Band High Power Amplifier (20 kW)

Whether we need 2kW or 20kW RF the power consumption is the same (90 kW)

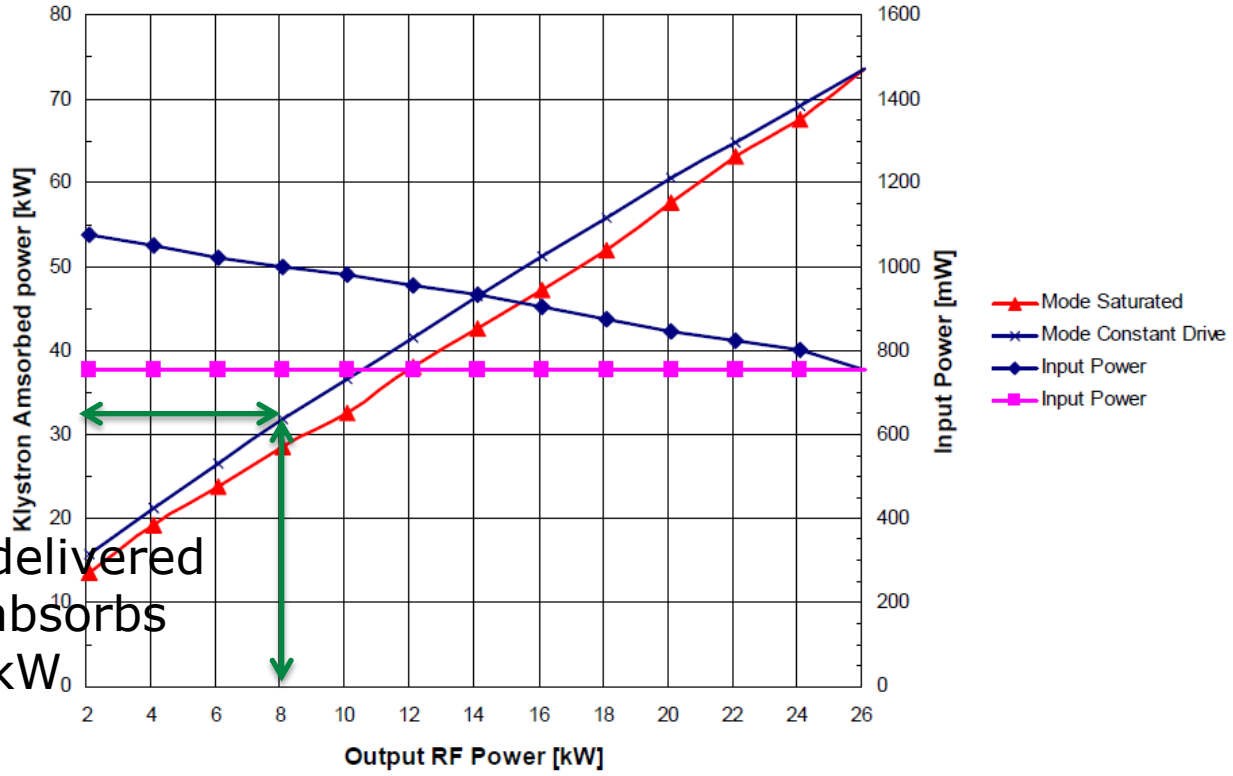
but

many passes need only 5 to 10 kW RF

How can we reduce the overall consumption?

RADIO-FREQUENCY AMPLIFIERS
X-Band High Power Amplifier (20 kW)

A new way of using the klystron has been studied to reduce the direct power consumption when low RF power required.



For 8 kW RF delivered the klystron absorbs less than 35 kW.

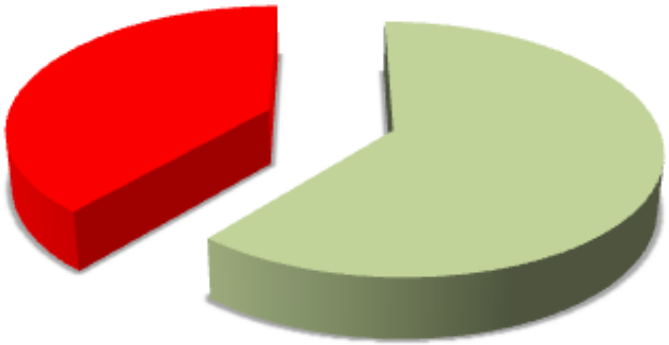
RADIO-FREQUENCY AMPLIFIERS
X-Band High Power Amplifier (20 kW)

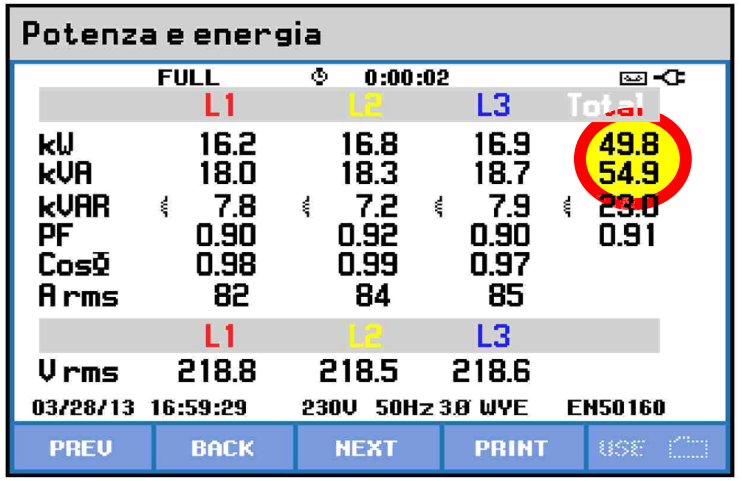
20 kW RF -> 90 kVA consumption

10 kW RF -> 55 kVA consumption

Direct savings of about 40%

And additional savings due to lower cooling requirements





RADIO-FREQUENCY AMPLIFIERS
X-Band Low Power Amplifier (DNK7703)

Classic Klystrons

Single collector voltage

All current at 9 kV.

Power consumption constant (even without RF)

(~ 12 kW)

New MSDC* Klystrons

Part of the current only at 3 kV, 6 kV or 9 kV.

Achieve savings at maximum RF power

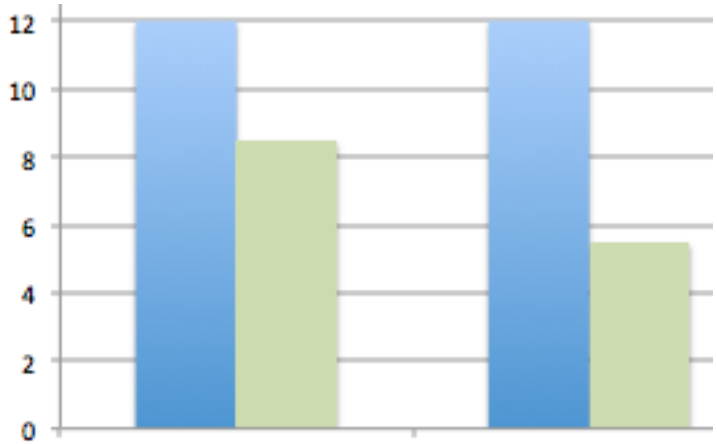
Even more efficient at lower RF power levels

*MSDC = Multi Spate Depressed Collector

RADIO-FREQUENCY AMPLIFIERS
X-Band Low Power Amplifier (DNK7703)

30% saving in power consumption at full RF power
old ~12 kW vs **new** ~ 8.5 kW

60% saving in power consumption at no RF power
old ~12 kW vs **new** ~ 5.5 kW



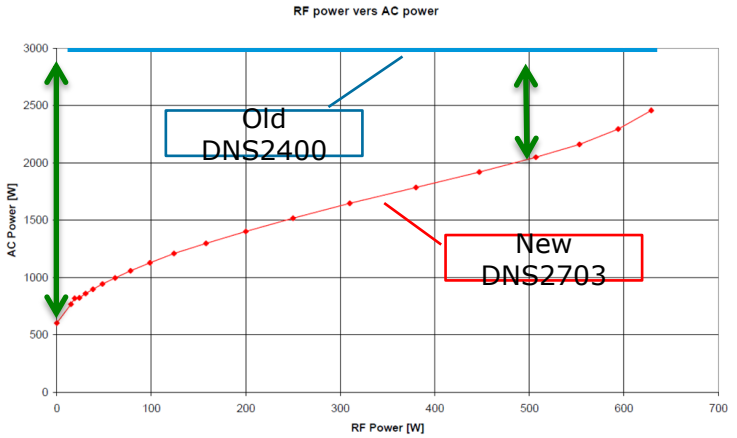
RADIO-FREQUENCY AMPLIFIERS
S-Band SSPA DNS2703

A new Solid-State Amplifier

4 modules instead of 16
less material used
less future waste

Use of Class AB transistors

- Power consumption reduced from 3 kW to 2 kW (for 500 W output)
- Reduced power consumption with RF OFF (600W)



OUR PROJECTS

A SOLAR PLANT IN AUSTRALIA

A SOLAR PLANT IN AUSTRALIA
Electricity public supply

Source:
ABC News
4 Apr. 2012

Statement from Lyndon Rowe of the Economic Regulation Authority

Massive price hike needed to meet electricity costs

Updated Wed 4 Apr 2012, 8:01pm AEST

There has been a recommendation the Government increase electricity prices by 23 per cent, adding more than $350 to the average household bill, in order to meet the true cost of its production.

PHOTO: Crews are working to restore power to those hit by cuts. (ABC)

MAP: Perth 6000

A draft report by the Economic Regulation Authority has found Synergy would need to increase the average household bill by $353 next financial year to achieve cost reflective pricing.

The ERA says residential tariffs would need to rise by 23 per cent on July 1, of which 8.4 per cent would be attributed to the carbon tax.

The State Government has already flagged an increase of five per cent, exclusive of the carbon tax, in last year's budget.

The ERA's Lyndon Rowe says there has already been a 57 per cent increase in tariffs since 2009 but more is needed to reach the true cost of producing power.

"Somebody is paying for this," he said.

"At the moment, there's a significant subsidy, I think in the order of $350 to $400 million, that the Government pays Synergy because we don't have cost reflective tariffs and that's paid for by WA taxpayers."

"Talking about a 23 per cent rise in electricity is not a welcome thing but I guess if there is a positive out of this, it is our view that after we get over this hump, in fact, the pressure from other increases is diminishing."

The Government will have the final say on any price increases.

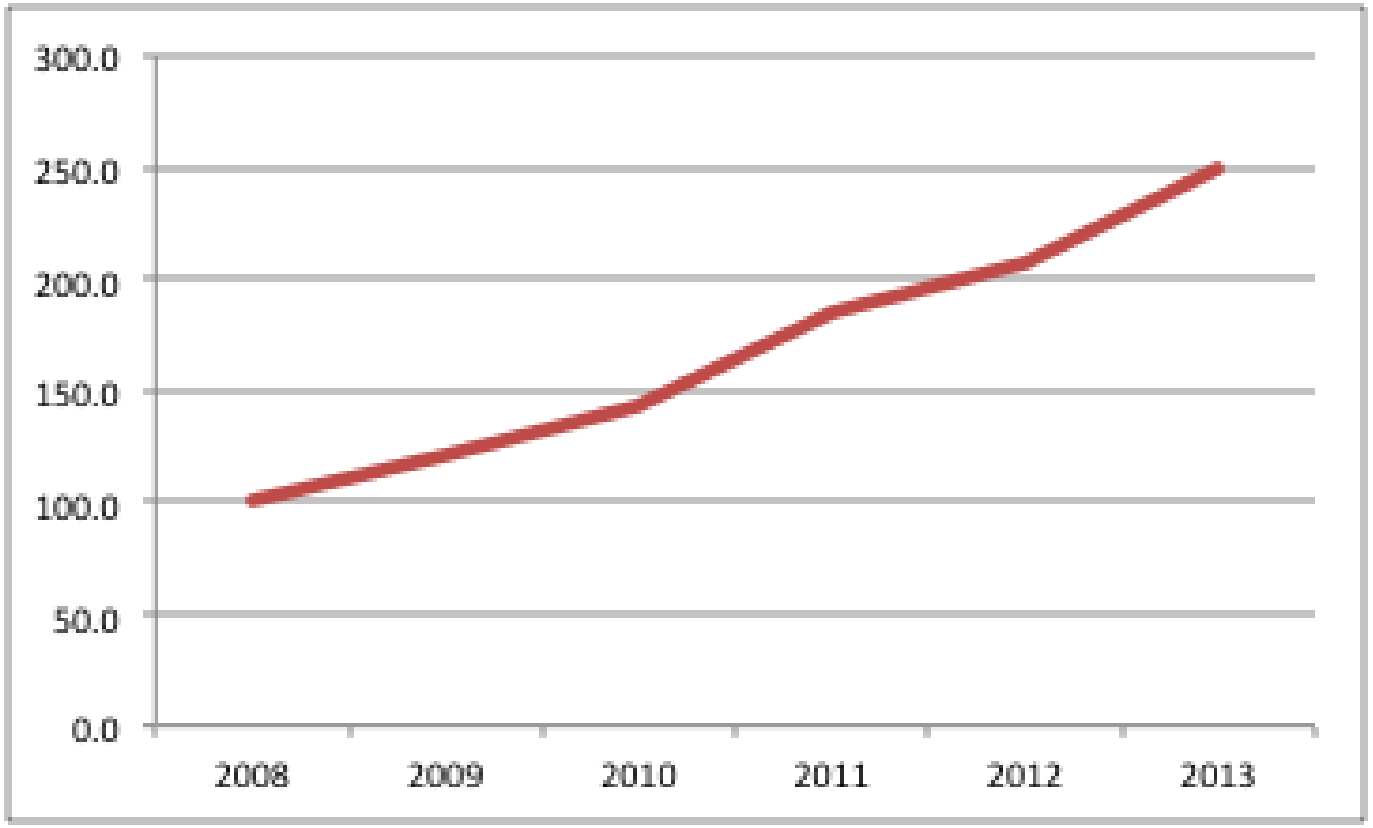
The Opposition's Bill Johnston says it needs to remember that households have already been hit hard.

"I think the Government needs to demonstrate it's got families in mind, needs to understand the problems that people in Western Australia have had because of the savage increases they've had to date," he said.

A SOLAR PLANT IN AUSTRALIA
Electricity Pricing in Australia

- Power Pricing has increased by approximately 57% since 2009
- Western Australian Government - goal of reaching Cost Reflective Pricing
  - estimated increase of at least 23% to meet CRP
- Government Subsidy to suppliers is still currently $350m to $400m p.a.
- Federal Government to introduce a Carbon Tax from July 1 2012
  - ~~Estimated to increase power cost by 9.3% from July 1~~
  - in addition to supplier price increase 3.5% from July 1

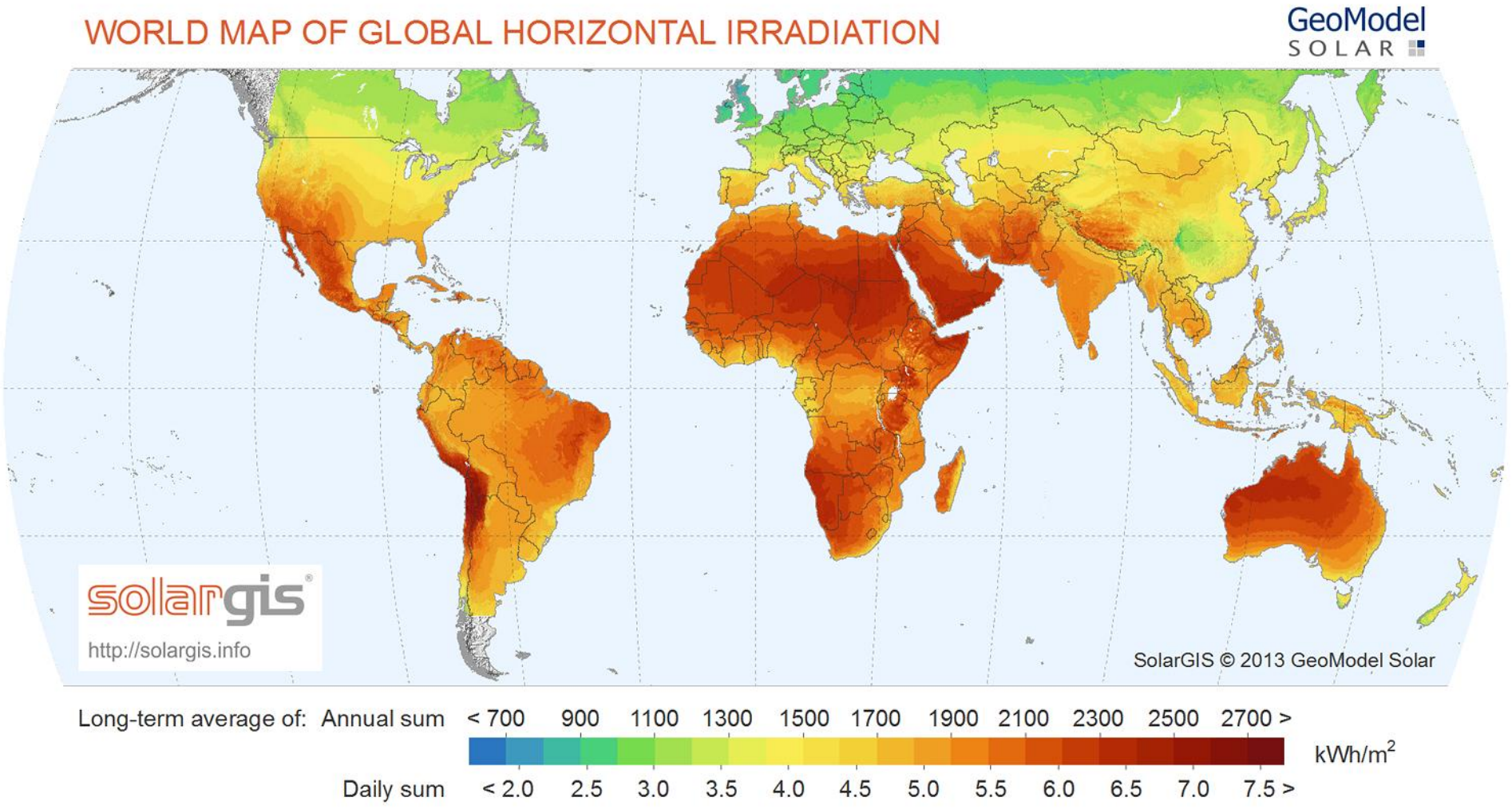
SOLAR PLANT IN AUSTRALIA
Electricity Prices Evolution



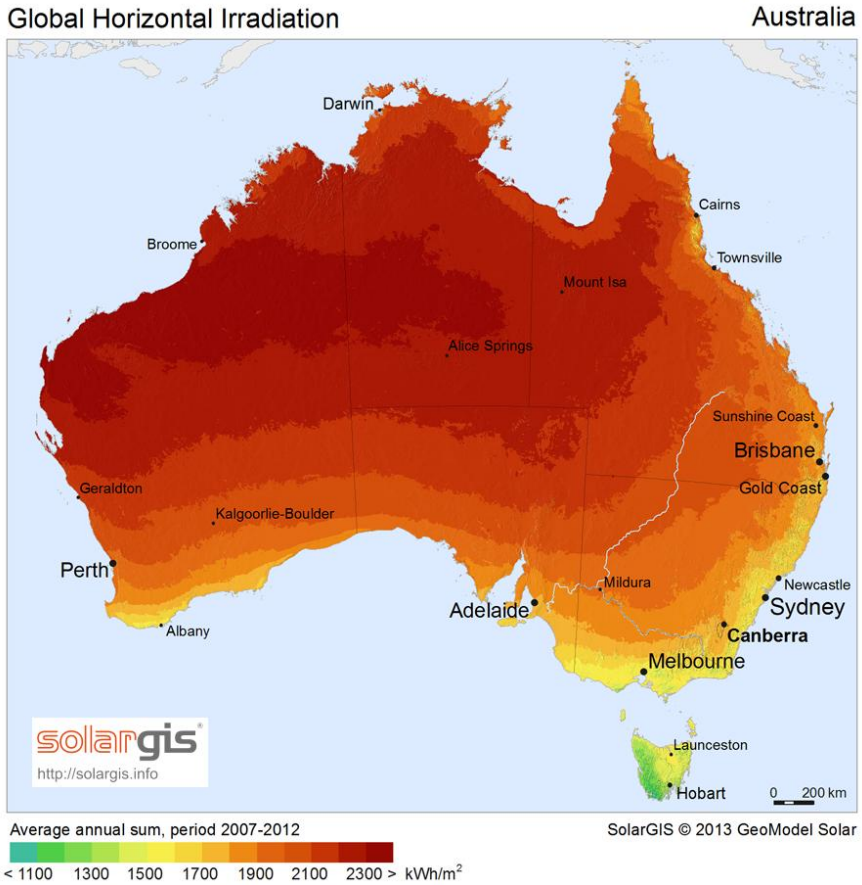
Source: http://www.finance.wa.gov.au/cms/content.aspx?id=15096

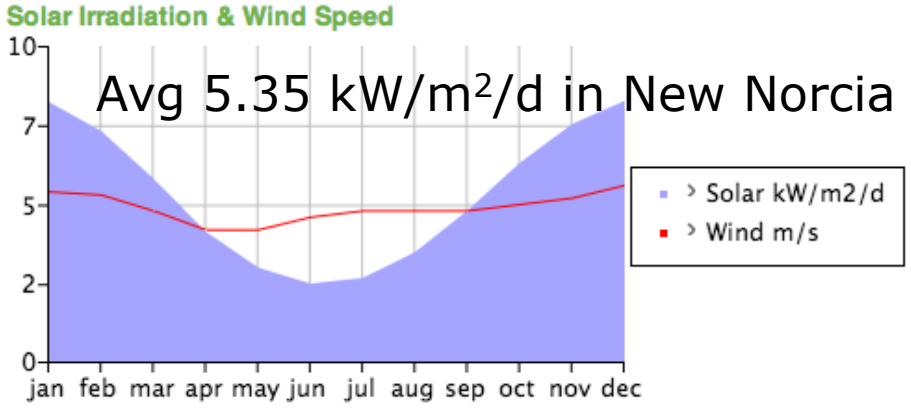
Prices multiplied by 2.5 within 5 years
More than 20% per year

A SOLAR PLANT IN AUSTRALIA



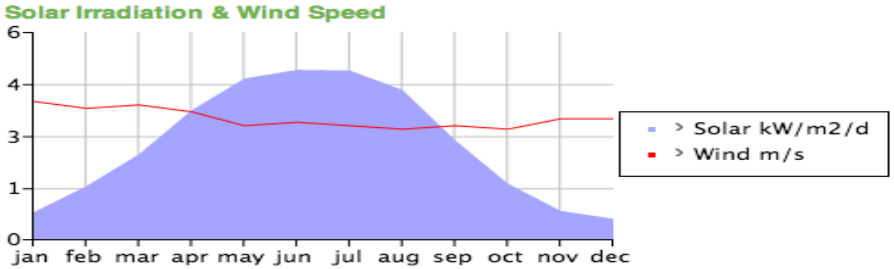
A SOLAR PLANT IN AUSTRALIA





Avg 5.35 kW/m²/d in New Norcia

Source:
http://www.energymatters.com.au/climate-data/



Avg 2.78 kW/m²/d in Frankfurt

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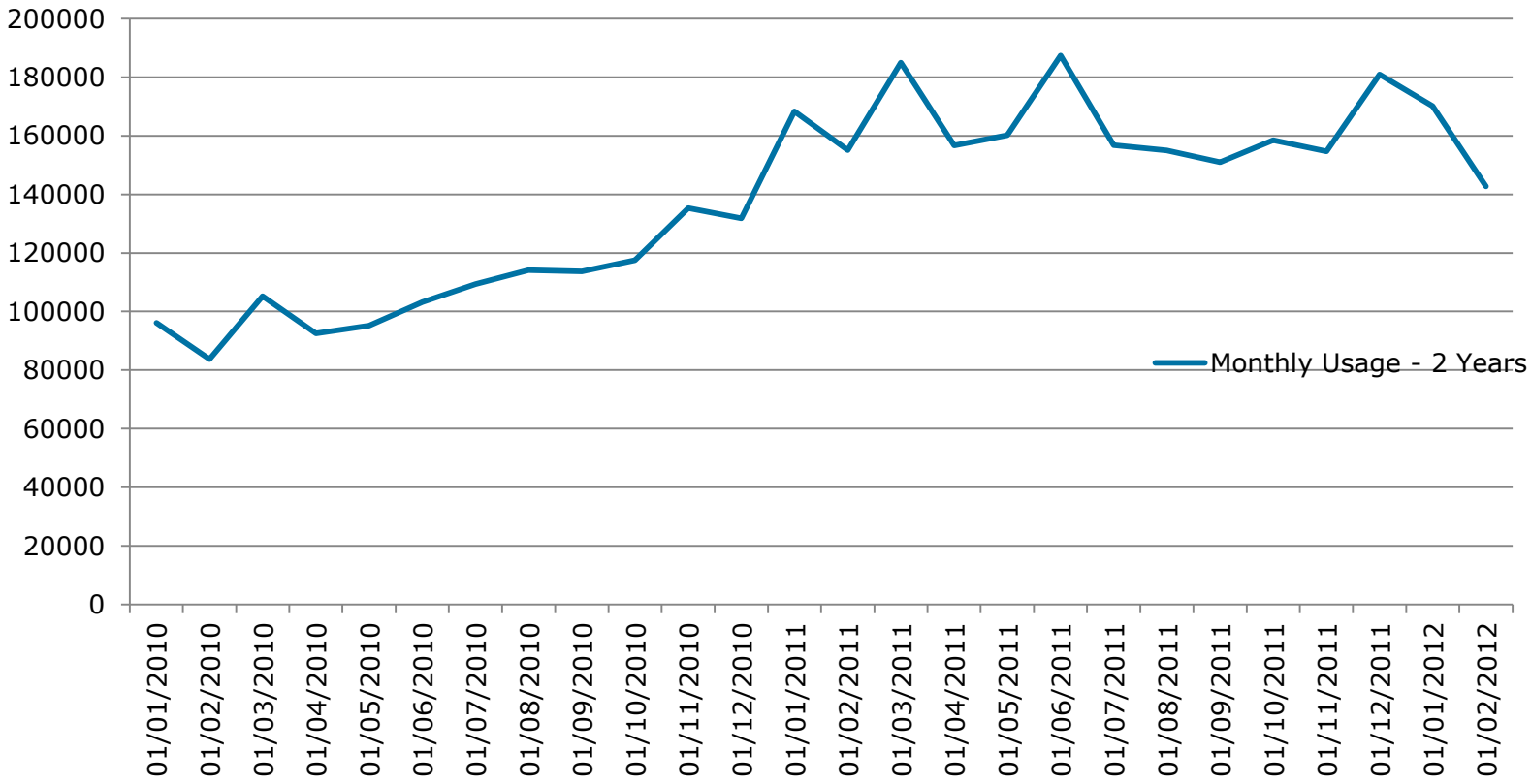
	MWp	Area (Millions km²)	W/km²	Population (Millions)	W/capita
EU	79.9	4.3	18.6	505	158.2
Germany	35.7	0.357	100.0	80.7	442.4
US	11.9	9.6	1.2	318.7	37.3
Australia	3.1	9	0.3	23.6	131.4
Spain	5.3	0.505	10.5	46.5	114.0

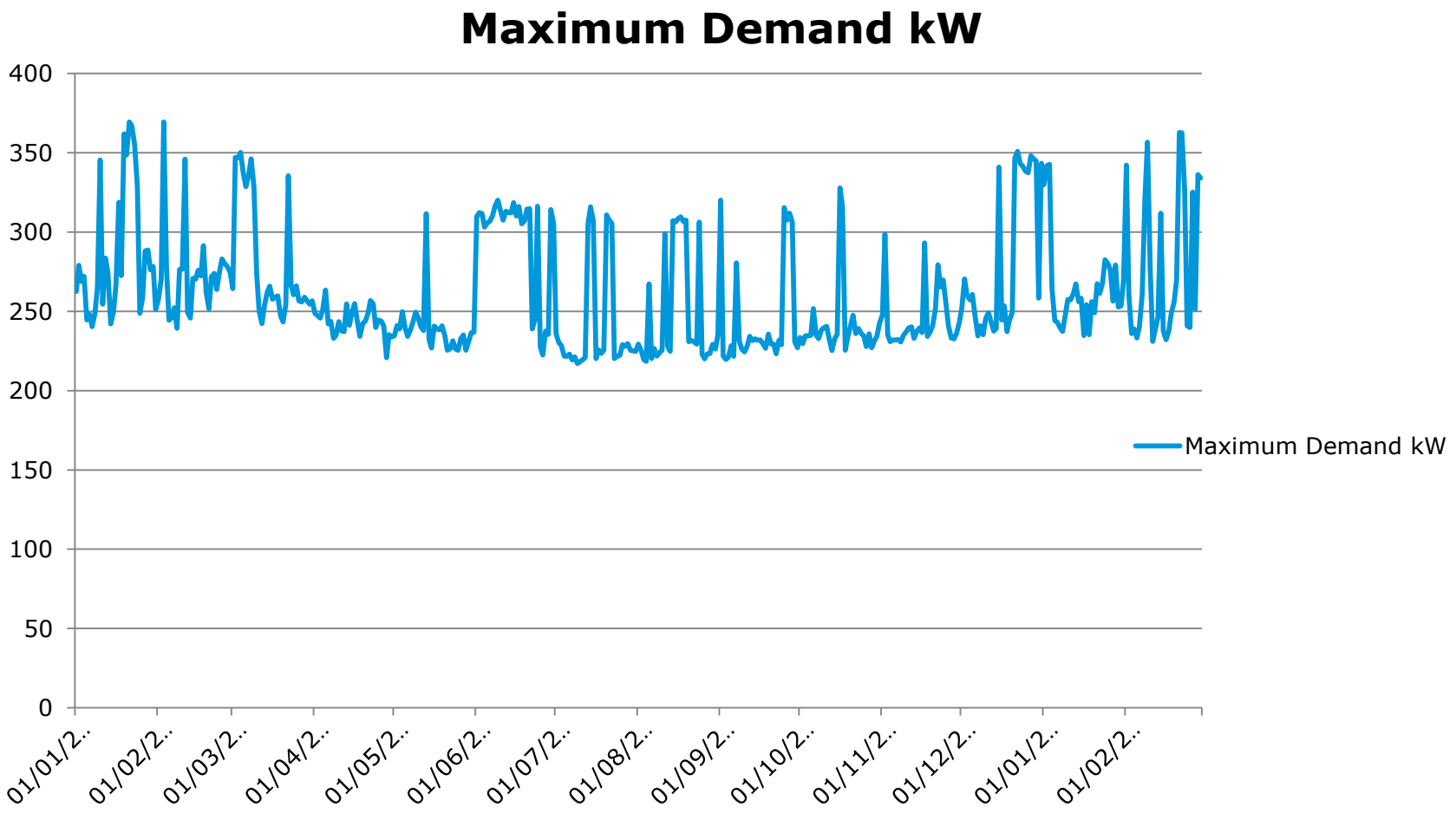
Source: Wikipedia

A SOLAR PLANT IN AUSTRALIA
New Norcia – Power Statistics

Monthly Usage (kWh) - 2 Years



A SOLAR PLANT IN AUSTRALIA
New Norcia – Power Statistics



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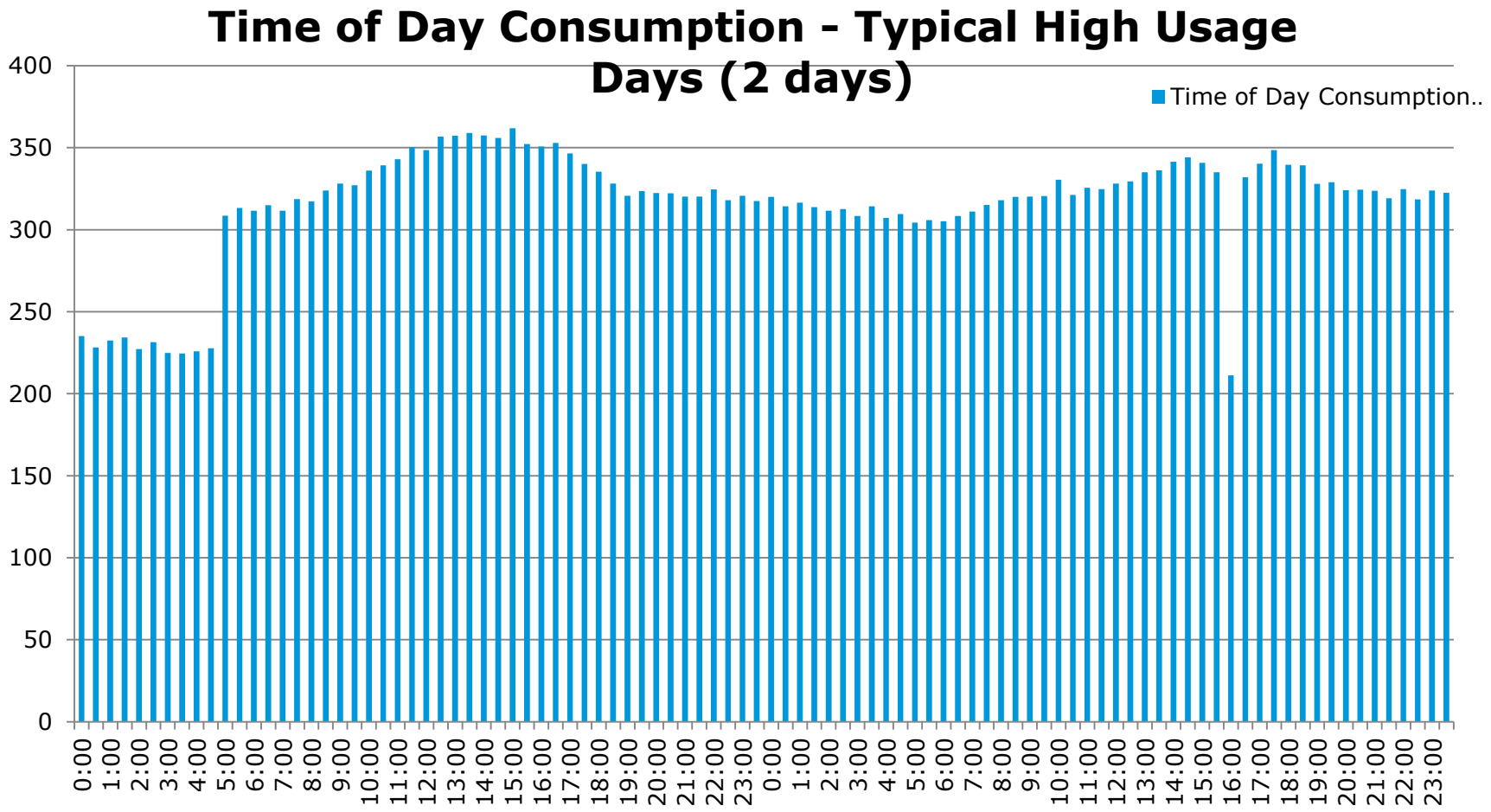

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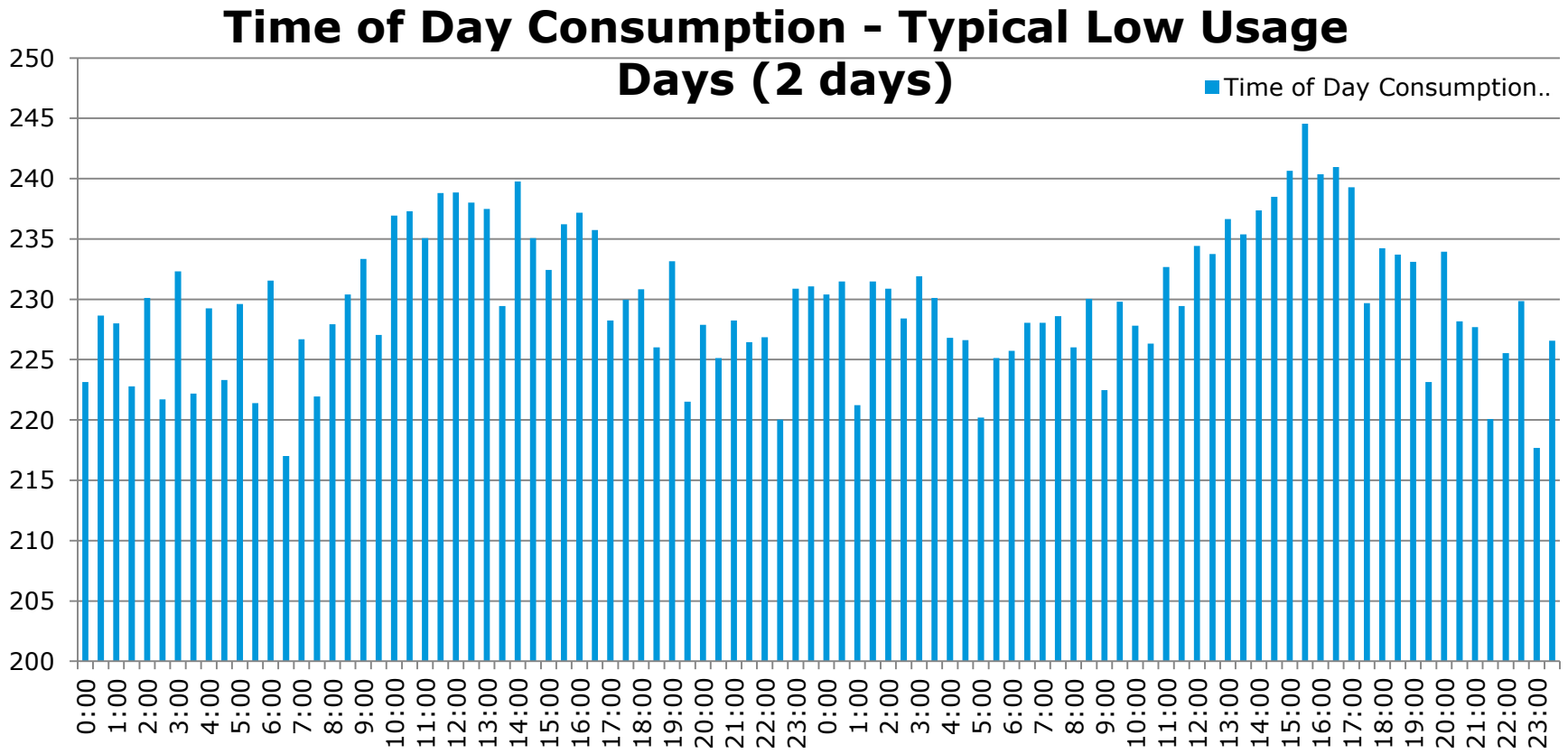

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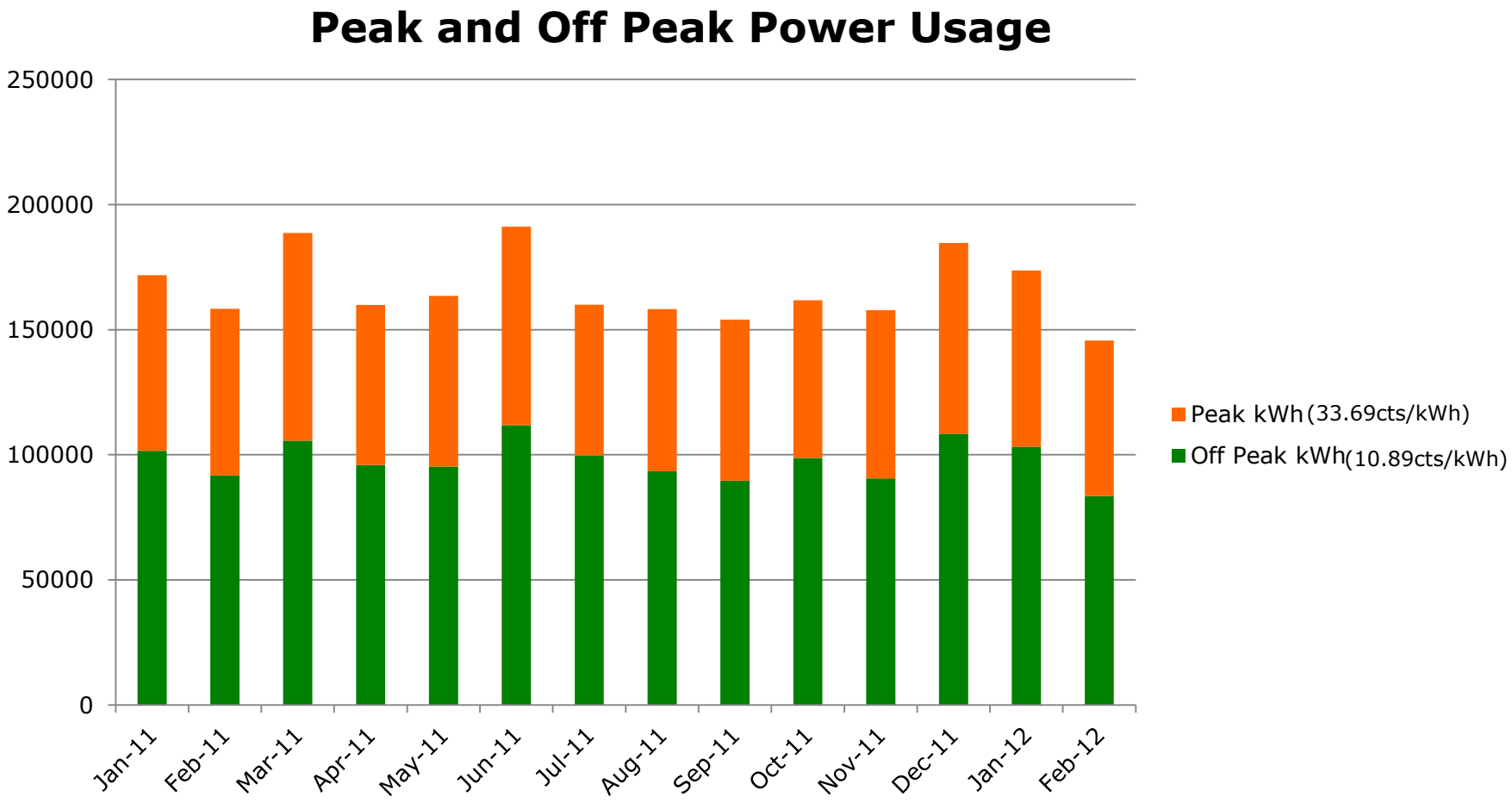


A SOLAR PLANT IN AUSTRALIA
Solar System Characteristics

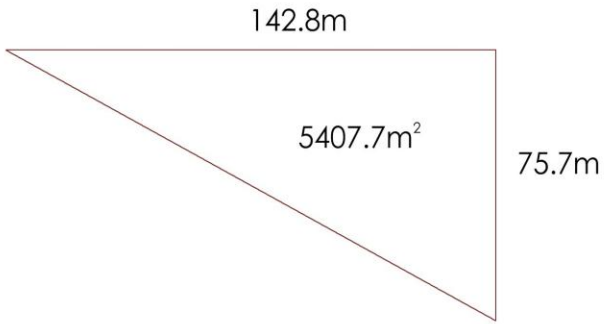
Based on analysis of the electricity consumption, we considered:

- A System Capacity of about 250kW
  - Estimated Output of between 400 and 457MWh/year
  - 400 tons of Carbon Dioxide per year estimated saving

- For example:
  - 48 strings of 18 300W-Panels
  - Ground mounted frames
  - Concrete strip footings
  - 864 panels / 259kW

A SOLAR PLANT IN AUSTRALIA
Implantation Options

A SOLAR PLANT IN AUSTRALIA
Implantation Options



A SOLAR PLANT IN AUSTRALIA
Business Case Considerations

Solar Array Size:	259kW
Azimuth:	30 degrees
Orientation:	North
System Life:	25 Years
Year 1 Energy Production:	450MWh
Annual Output Reduction:	0.8%/year
Capital Cost	$1M
Maintenance Cost:	$6,000/year (increasing 5%/year)
Replacement Cost:	$100,000 every 10 years
Peak Tariff:	$0.3369/kWh
Off-Peak Tariff:	$0.1089/kWh
Electricity Tariff Increase:	7.5%/year (for Business As Usual)

A SOLAR PLANT IN AUSTRALIA
Levelised Cost of Energy (LCOE)

LCOE accrues all the costs of a power generation system over its lifetime *(25 years in our case)* such as

- capital costs *($1M in our case)*
- maintenance and operation costs
- equipment replacement costs
- Fuel costs ($0 in our case)

These costs are divided by the projected energy production of the system over the same time period.

This produces a levelised $/kWh figure that can be compared with other generation sources or the retail cost of energy over the lifetime of the system.

A SOLAR PLANT IN AUSTRALIA
Production and Costs

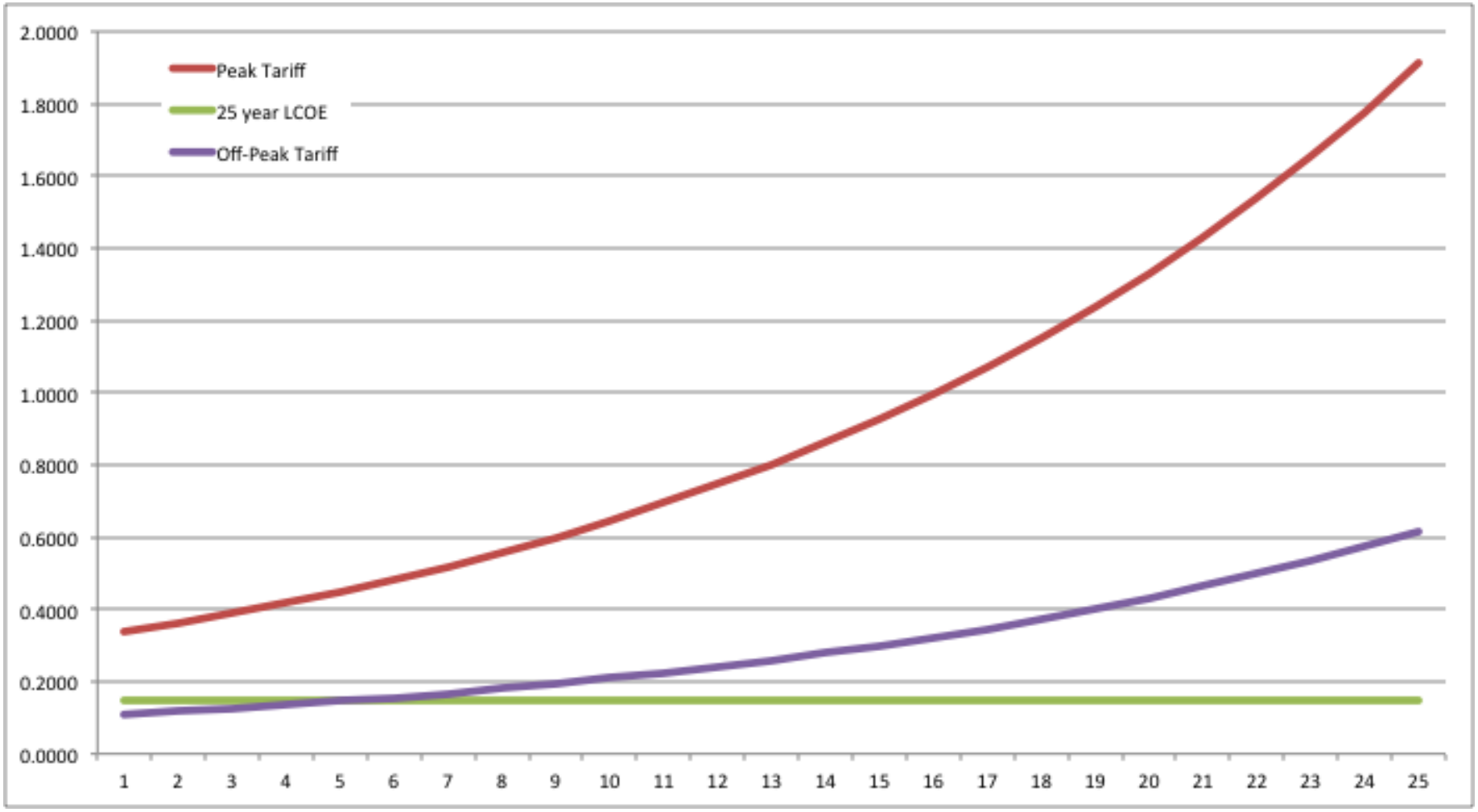
In our case, we would produce over the lifetime of the system

10.23GWh at a rate of **$0.1452/kWh**

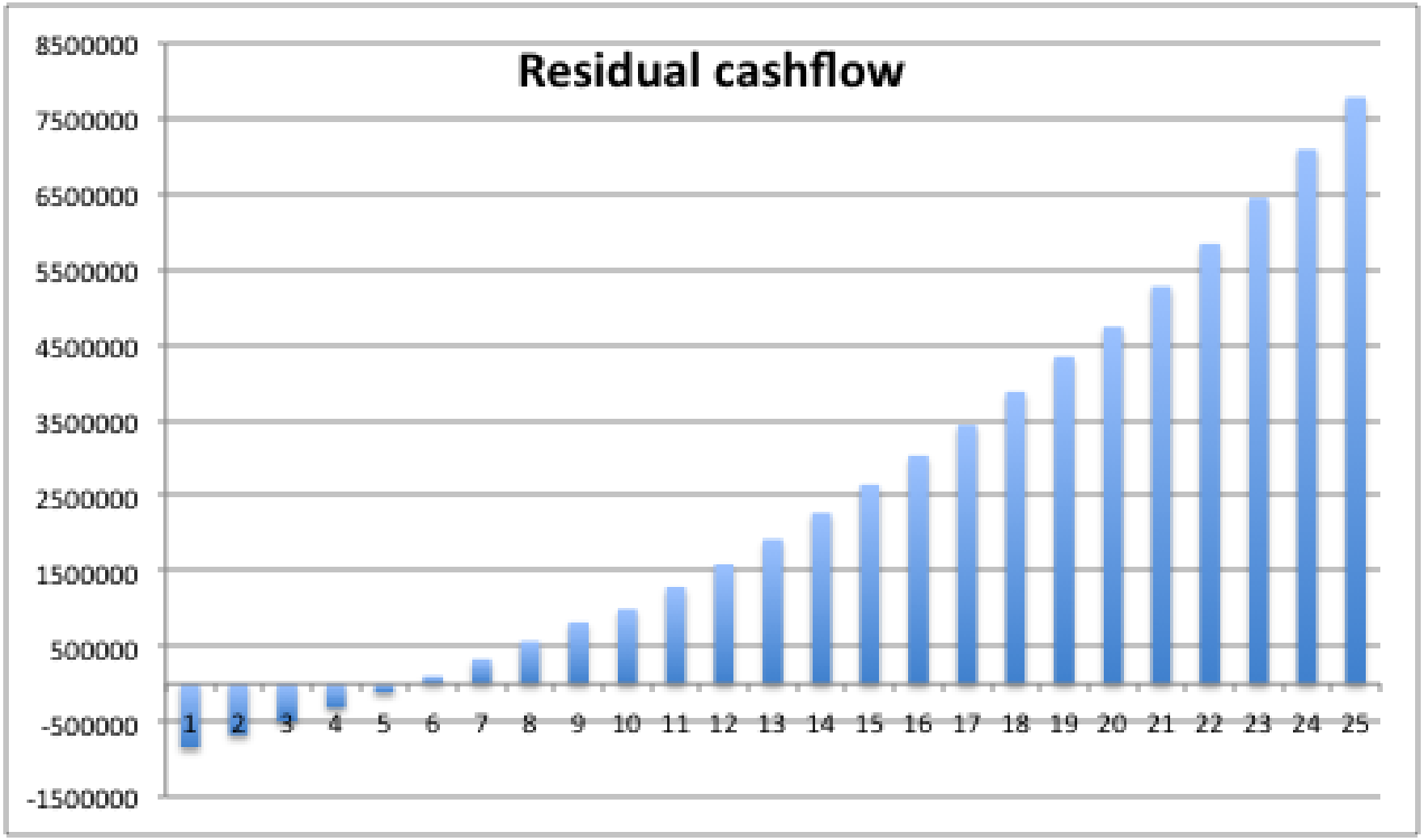
($0.1294/kWh with LGC* as of 2016)

* Large Scale Generation Certificate

A SOLAR PLANT IN AUSTRALIA
Costs comparison



A SOLAR PLANT IN AUSTRALIA
Estimated Payback



A SOLAR PLANT IN AUSTRALIA
Business case summary

	5%	7.5%	10%
Investment Payback	6years	6years	6years
Savings after 20yrs	3.3 M$	4.7 M$	6.6 M$
Savings after 25yrs	5.1 M$	7.8 M$	11.7 M$

Estimated System Cost is approx. $1 million AUD

A SOLAR PLANT IN AUSTRALIA

IT LOOKS GOOD

SO LET'S GO FOR IT…

A SOLAR PLANT IN AUSTRALIA
Validation of the Project

Our first step was to ask for a commercial proposal in order to validate our assumptions.

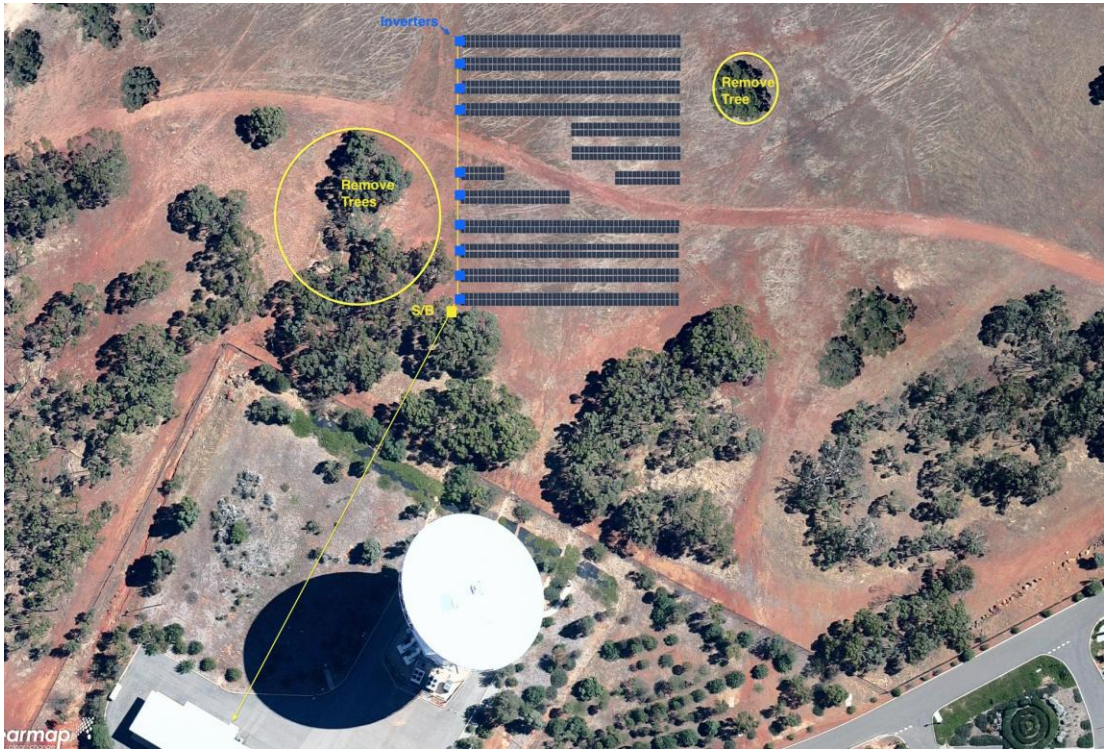
A SOLAR PLANT IN AUSTRALIA
Validation of the Project

Commercial offer:

984 panels of 255 W each

Cost around AU$ 800k

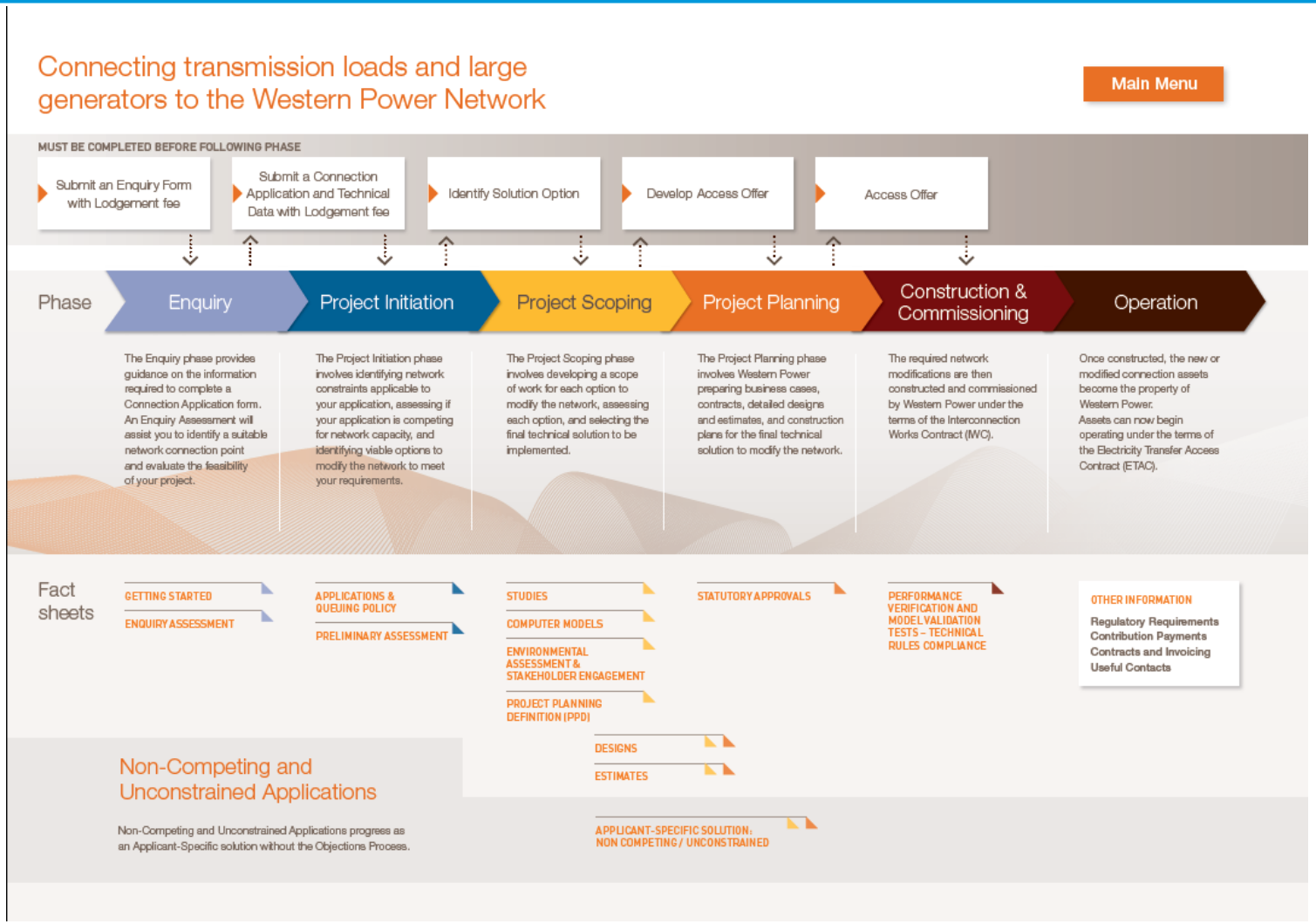
ROI : 4.9 years



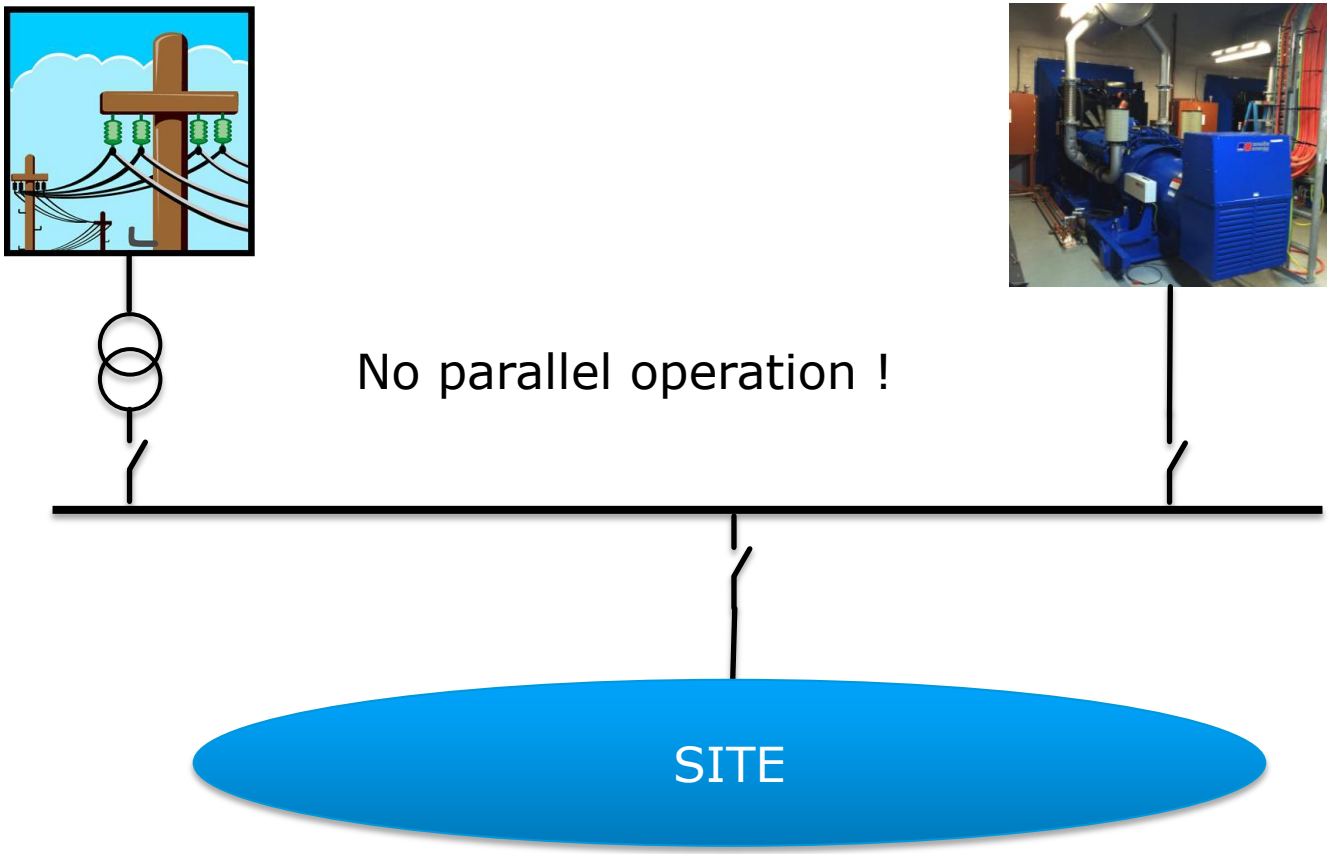
A SOLAR PLANT IN AUSTRALIA
Authorities Approval

- **Building Permit**
- **Electricity Supplier Approval**

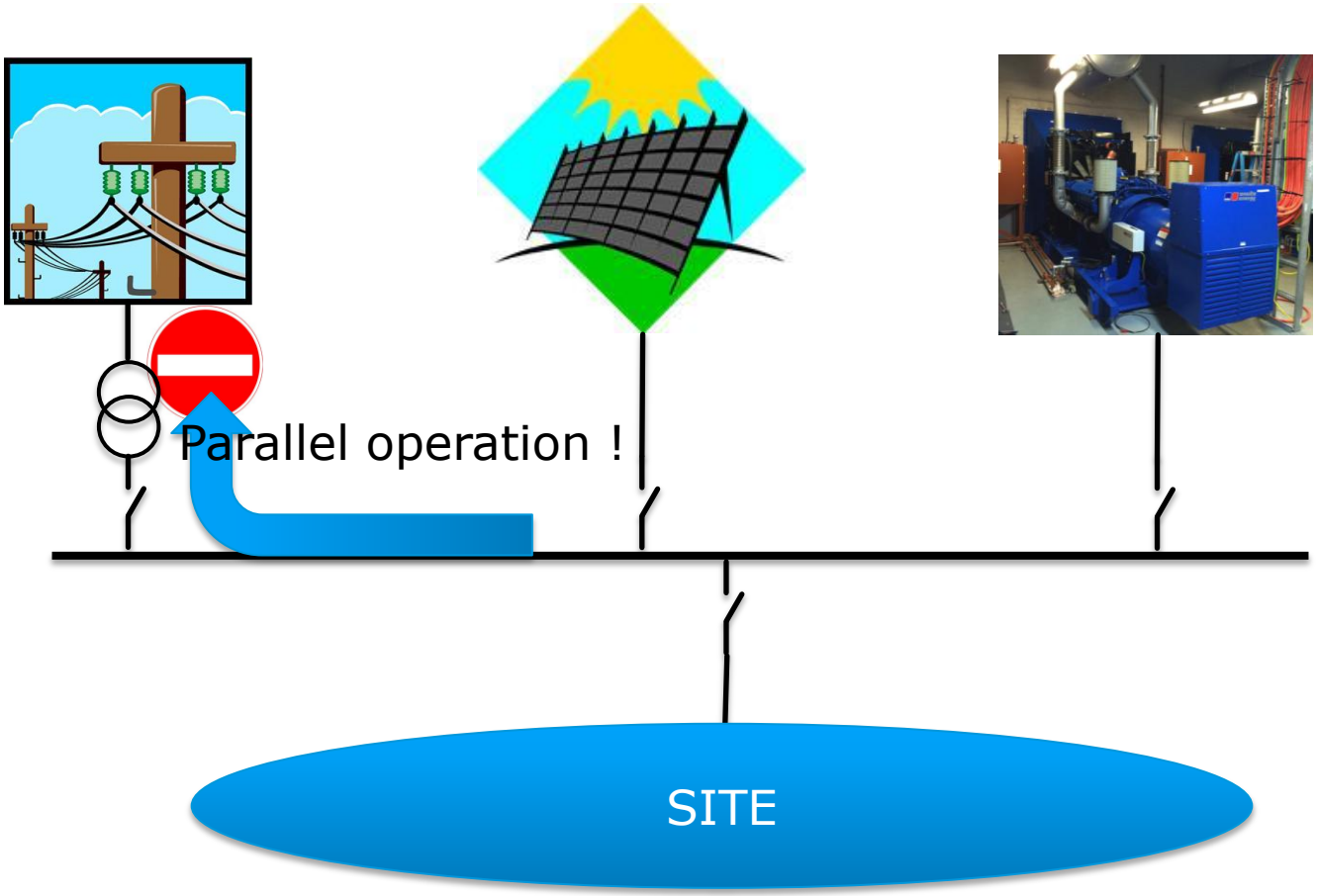
A SOLAR PLANT IN AUSTRALIA
Electricity Supplier Approval

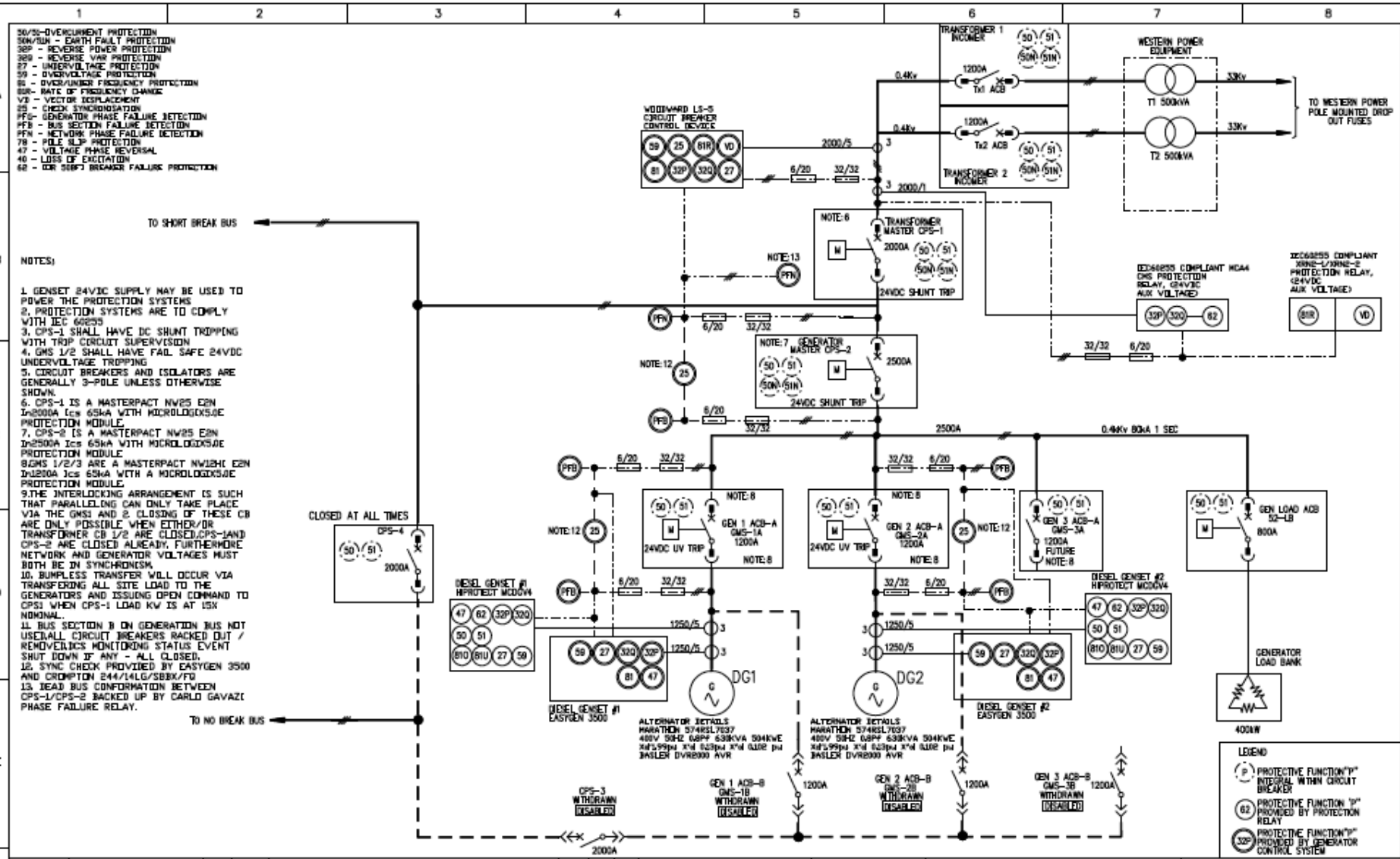


A SOLAR PLANT IN AUSTRALIA
Today's network



A SOLAR PLANT IN AUSTRALIA
Tomorrow's network





DRAWING NO.	DESCRIPTION	ISS	DATE	REVISION/ISSUE	DWN	CKD	APPD
		C	14/9/14	CHANGES TO VOLTAGE REFERENCE ARRANGEMENT	TE	BB	TE
		B	12/8/14	CHANGES TO LAYOUT ARRANGEMENT	TE	BB	TE
		A	3/2/14	ORIGINAL ISSUE	TE	BB	TE
ASSOCIATED DRAWINGS							

DO NOT SCALE
IF IN DOUBT ASK
DIMENSIONS IN mm

MTU Detroit Diesel Australia
22 STOCKYARDS LANE
HAZELMERE W.A. 6055
AUSTRALIA

DRAWN	T.EDWARDS		
CHECKED	S.HUCHLER	DATE	25/9/13
APPROVED	T EDWARDS	SCALE	NTS

PROJECT: ESA -CONTROL
TITLE: DEEP SPACE GROUND STATION NEW NORCIA BUMPLESS TRANSFER PROTECTION
JOB NO. M11500
DRAWING No. DWA-1-70
SHEET 1 OF 1
ISSUE C
A3

EXTERNAL LIGHTS IN SPAIN

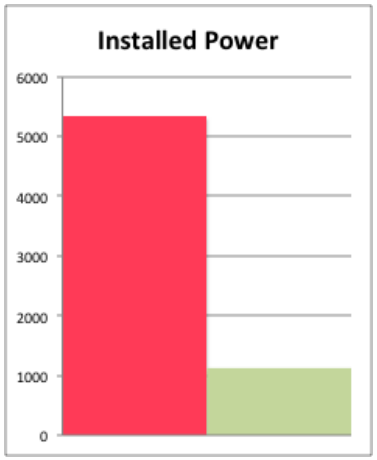
EXTERNAL LIGHTS - Cebreros

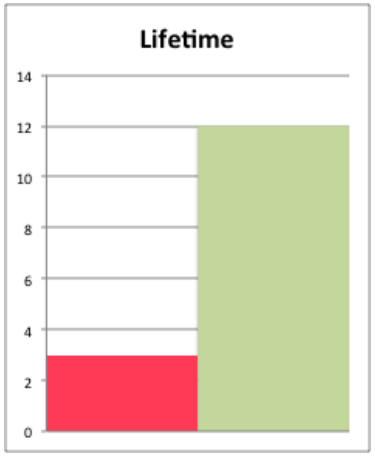
We plan to replace in our station of Cebreros – Spain (Deep Space Antenna 2) conventional floodlights by LEDs

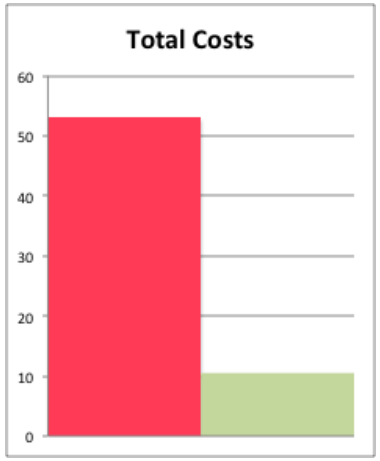
EXTERNAL LIGHTS – Cebreros
Some figures

Current Installation	
18 Lamp posts	5330 W
Annual Consumption	22373 kWh
Lifetime	3 years
Maintenance costs	45€/lamp
Electricity costs	0,1084 €/kWh
Yearly increase	6%
Overall costs after 12y	53k€

Future Installation	
18 Lamp posts	1123 W
Annual Consumption	4716 kWh
Lifetime	12 years
Maintenance costs	-
Electricity costs	0,1084 €/kWh
Yearly increase	6%
Overall costs after 12y	10.5k€





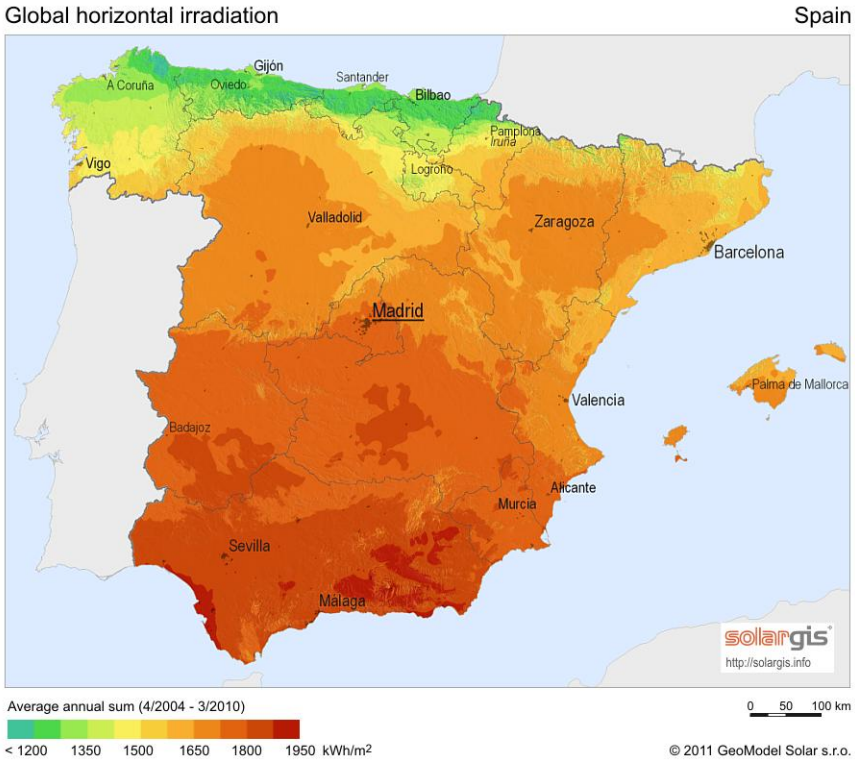


Project Cost: 9k€

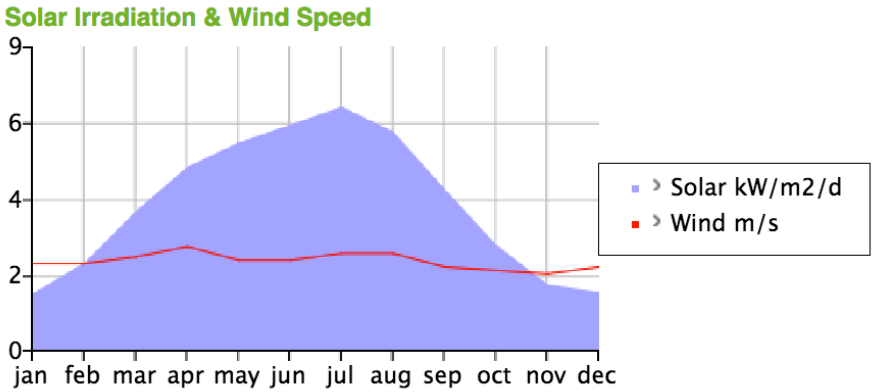
Payback:
Less than 4 years

A SOLAR PLANT IN SPAIN

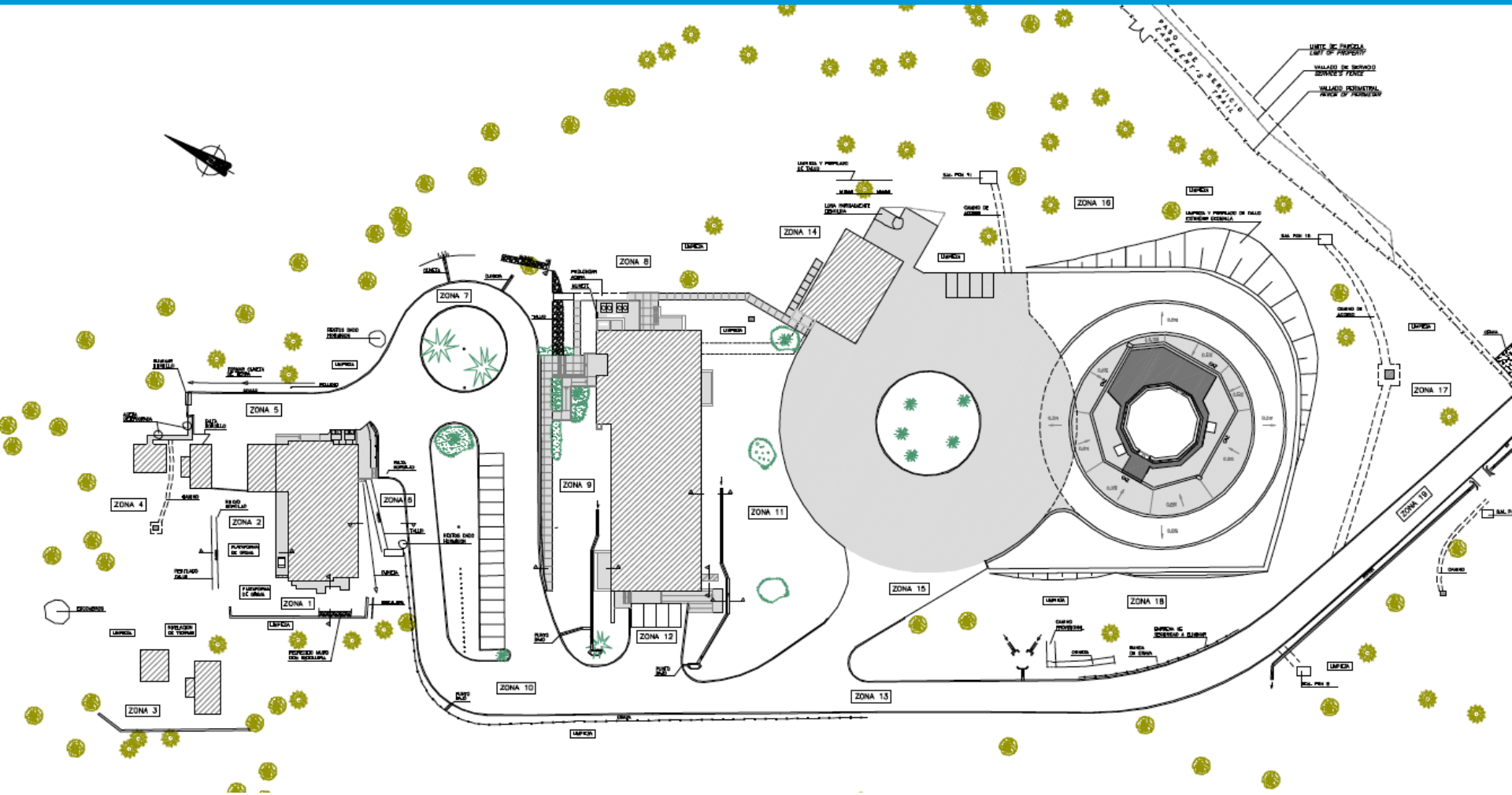
A SOLAR PLANT IN SPAIN



Avg 4.35 kW/m^2/d in Madrid area

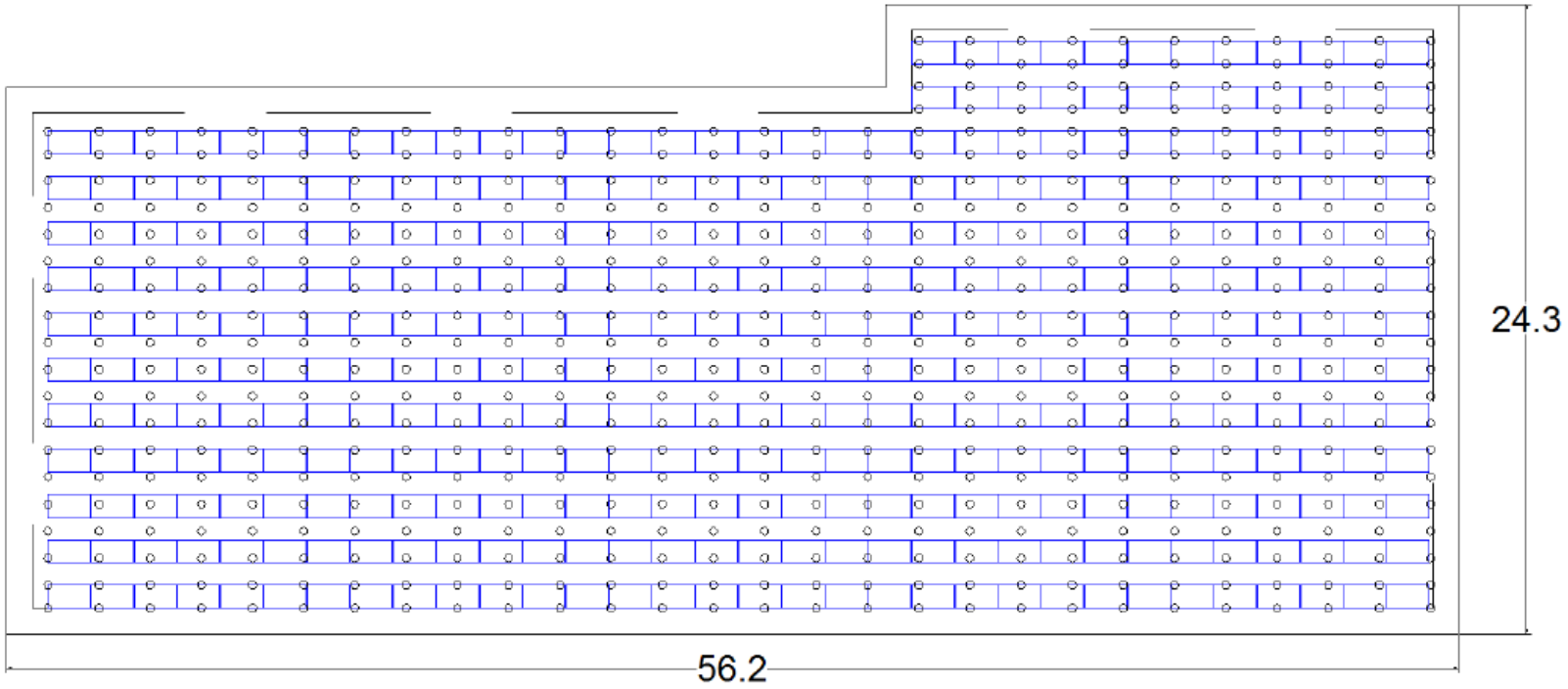


A SOLAR PLANT IN SPAIN
A different approach

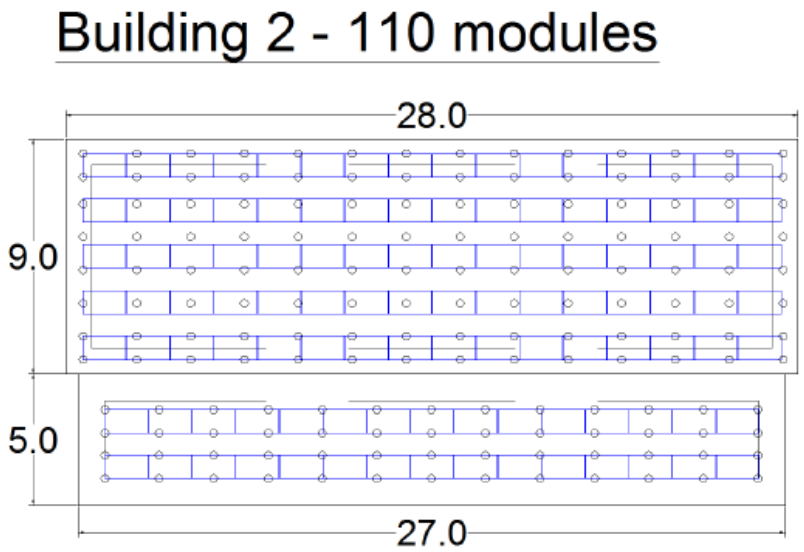


A SOLAR PLANT IN SPAIN
A different approach

Building 1 - 376 modules



A SOLAR PLANT IN SPAIN
A different approach



A SOLAR PLANT IN SPAIN
A different approach

Module slope : 24°
Distance between modules : 1,75m

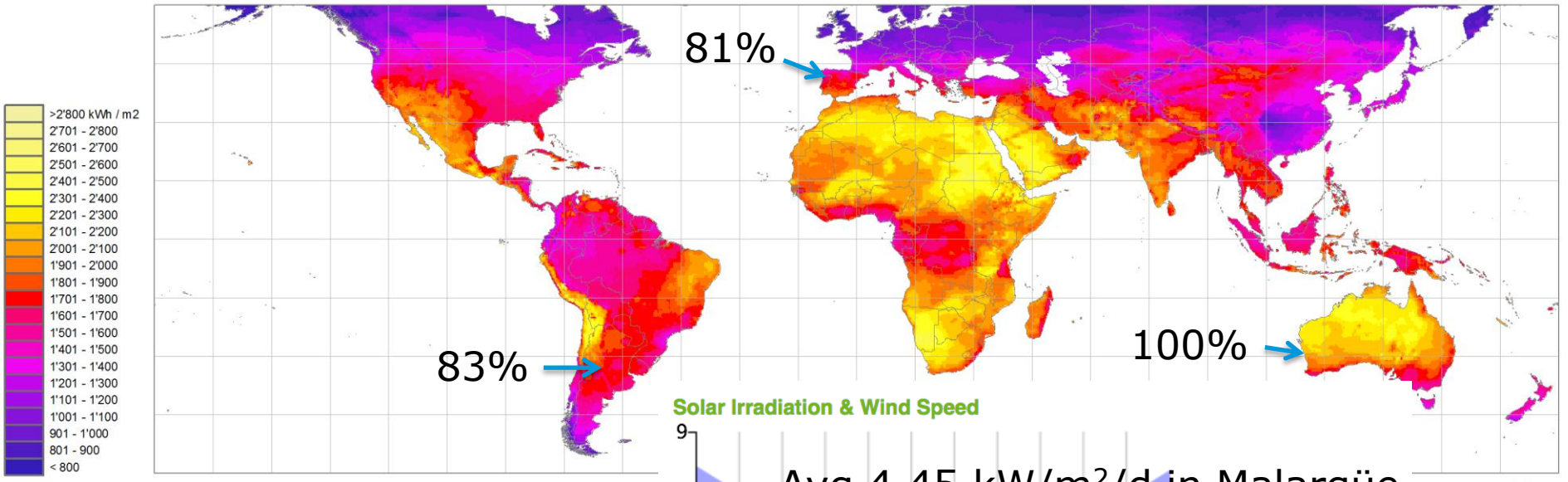
Building	1	2	3	4	6	Total
Area [m²]	1256	388	248	37	37	1966
Orientation	-30	-30	0	-30	-30	
Number of PV modules	376	110	70	9	9	574
Installed Power [kWp]	97,76	28,6	18,2	2,34	2,34	149,24
Yield [kWh/kWp/an]	1544	1544	1544	1544	1544	1544
Yearly production [kWh]	150941	44158	28101	3613	3613	230426
Number of console Fix	565	164	99	15	15	858

AND AFTER?

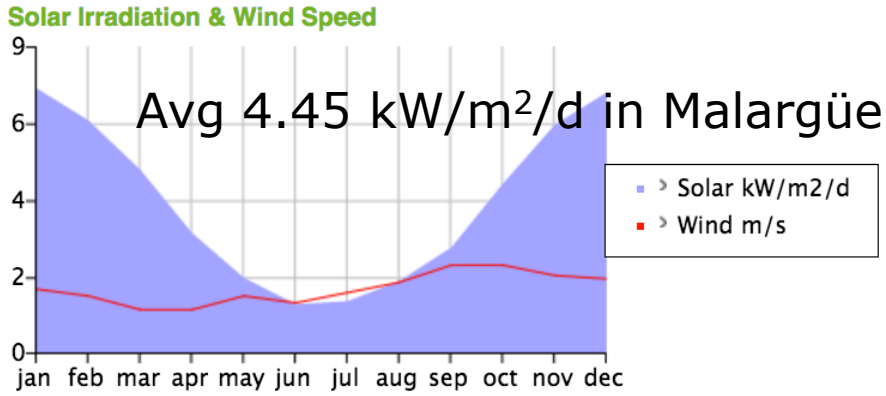
AND AFTER…

A SOLAR PLANT IN ARGENTINA?

Yearly sum of Global Horizontal Irradiation (GHI)



Source: Meteonorm 7.0 (www.meteonorm.com); uncertainty 8%
Period: 1986 - 2005; grid cell size: 0.25°



mber 2012 METEOTEST

AIR-CONDITIONING - REVISITED?